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SCIENCE

28 April 1961

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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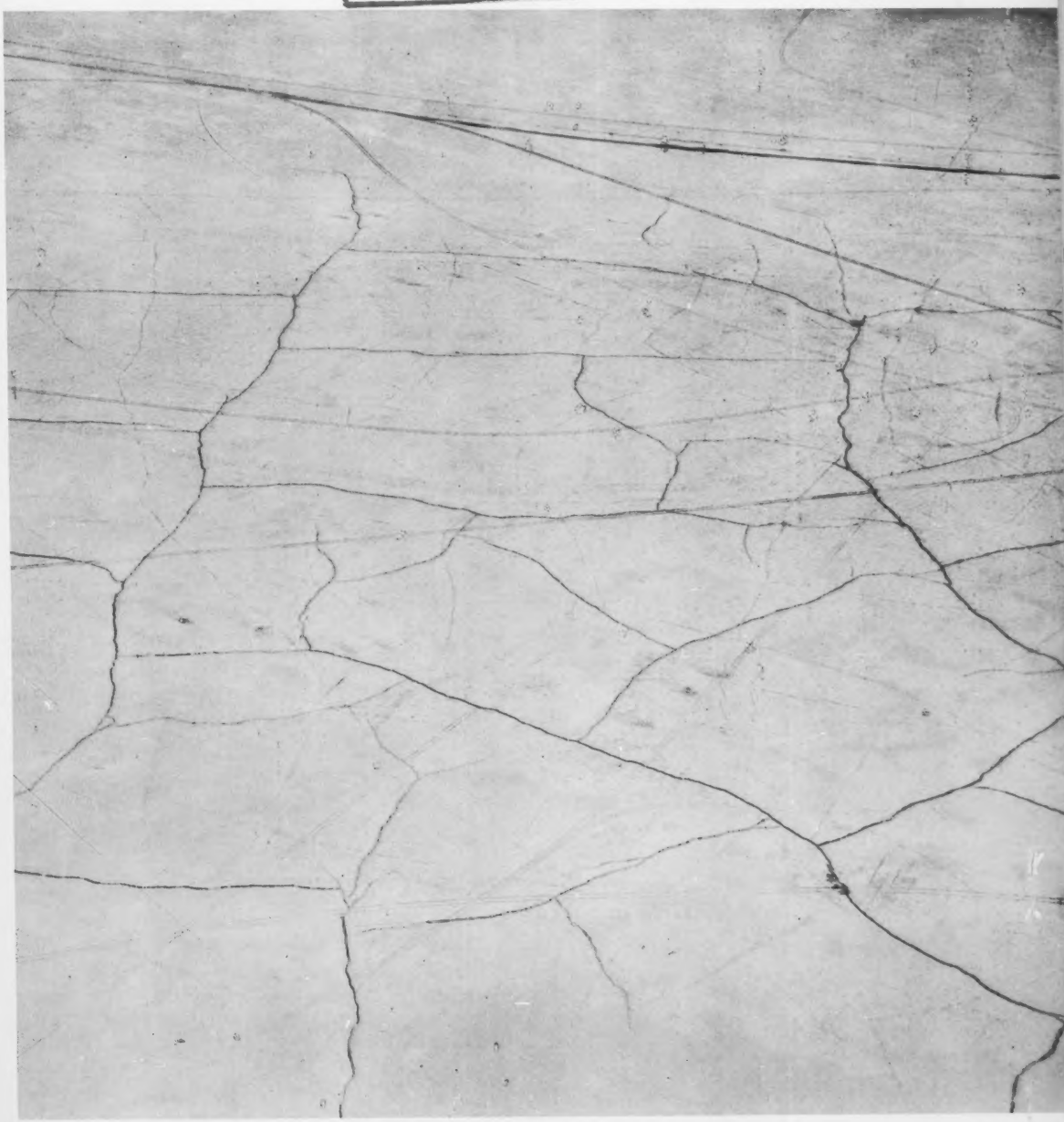

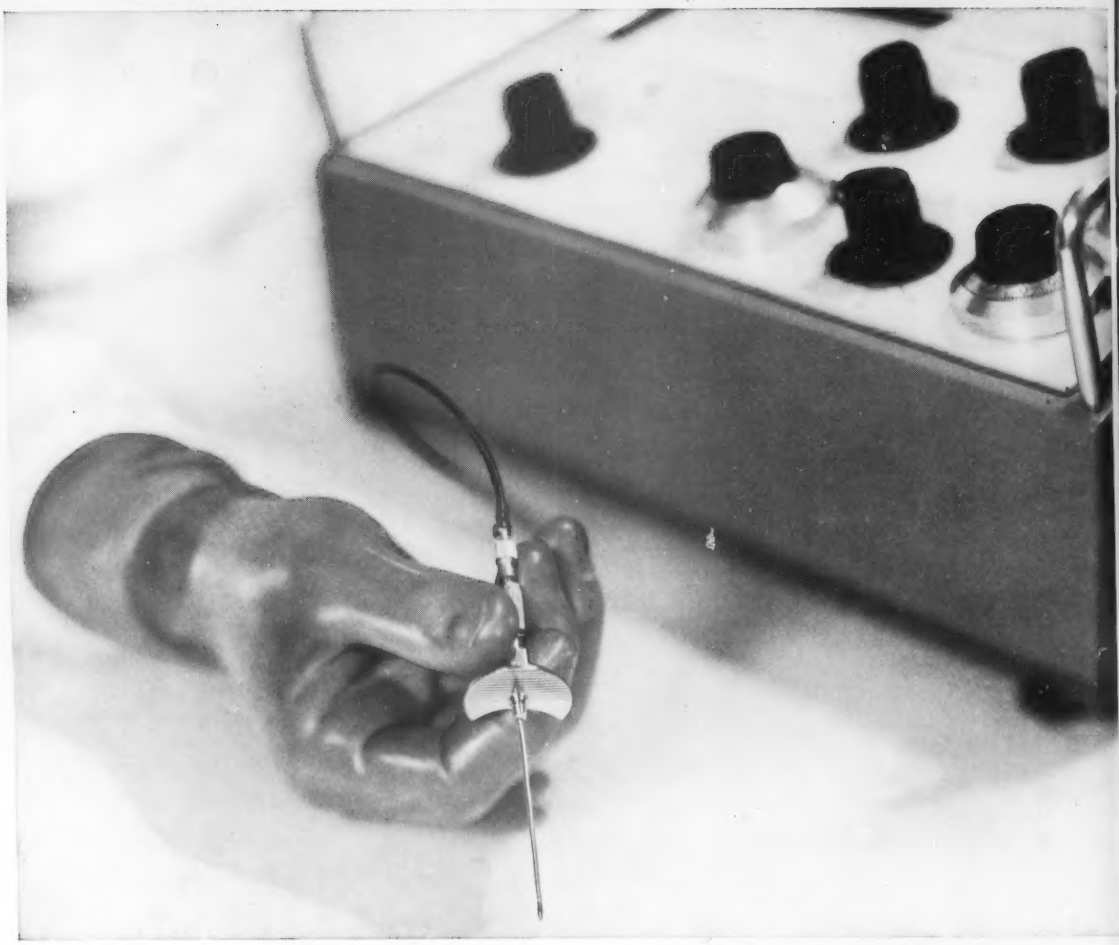

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Oblique aerial photograph of desiccation fissures on the Black Rock Desert, Nevada. The car tracks shown in the foreground and elsewhere in the photograph indicate the scale of the fissures. See page 1359.

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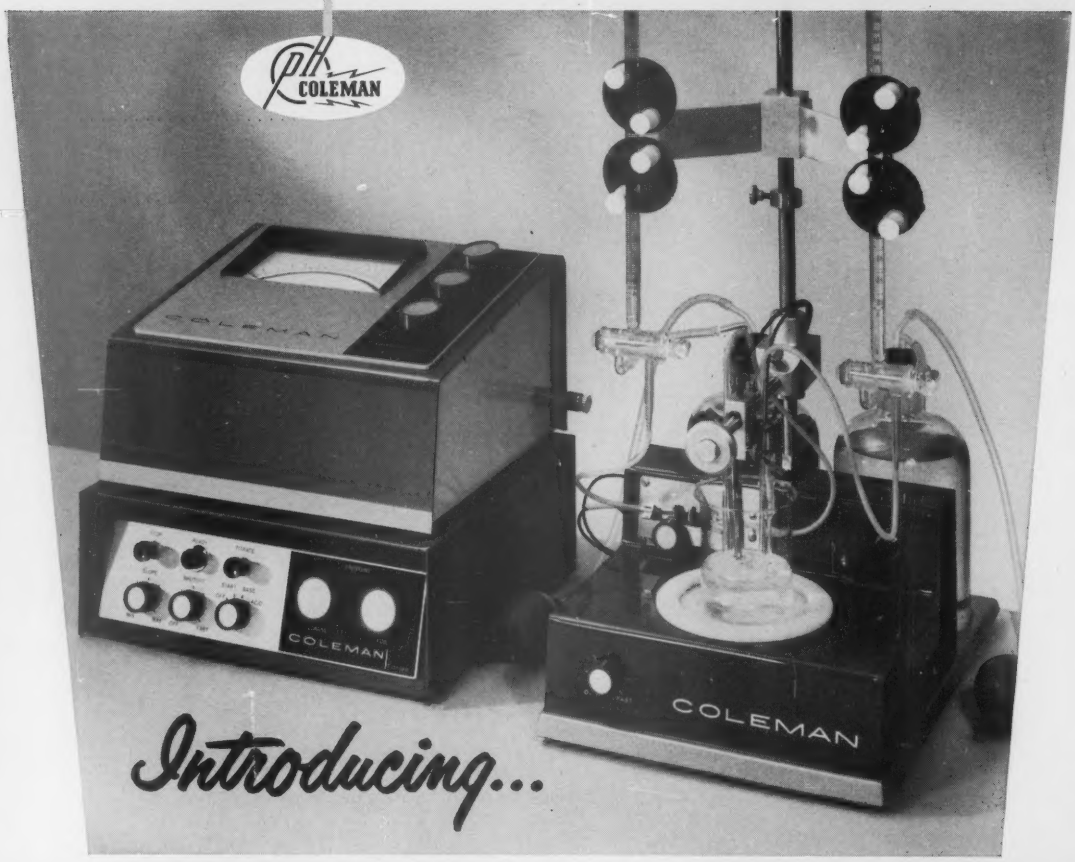

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*American Journal of Clinical Pathology Vol. 33. No. 2. February 1960, pp 144-151 "Application of Refrigerated Microtome in Surgical Pathology" by Bernard Klionsky, M.D. and Othello D. Smith, M.D.

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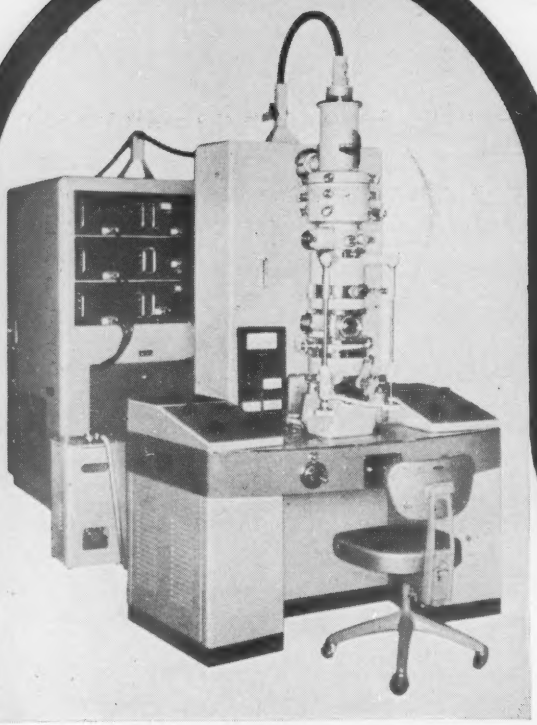

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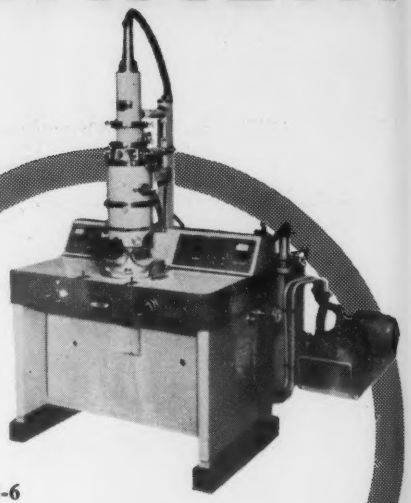

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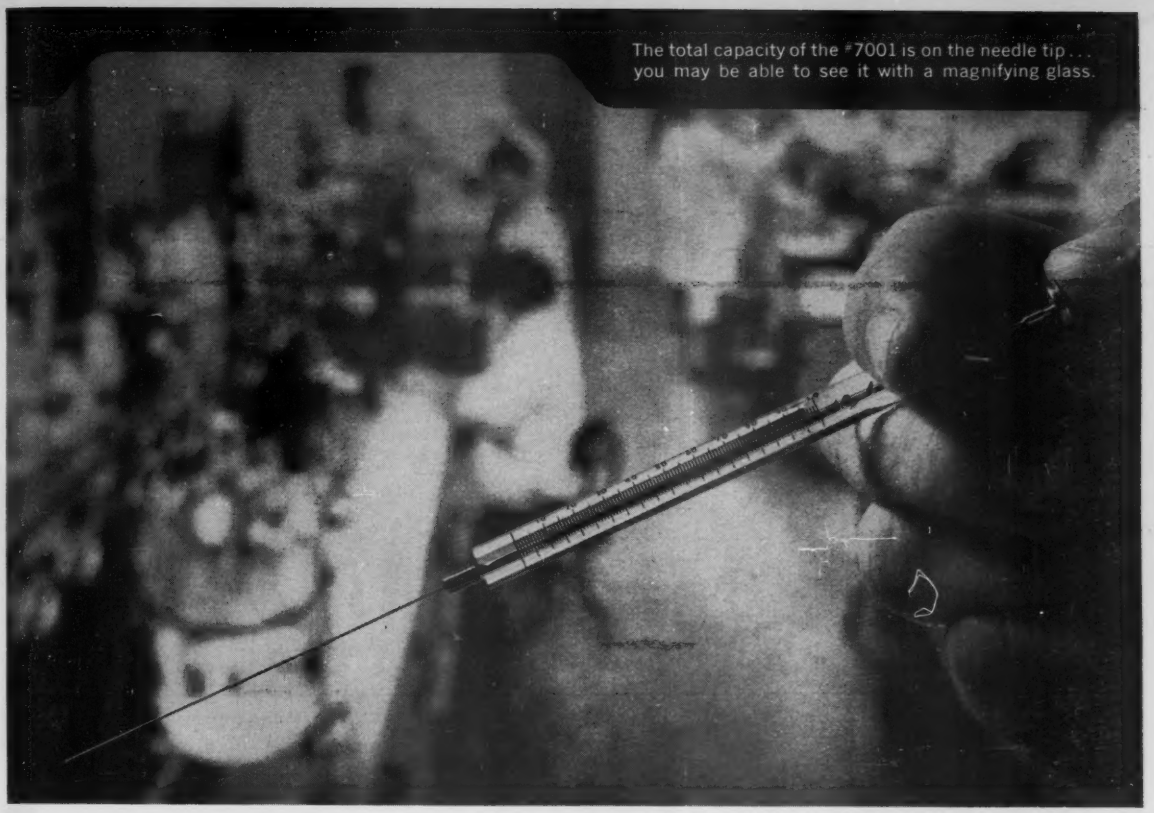

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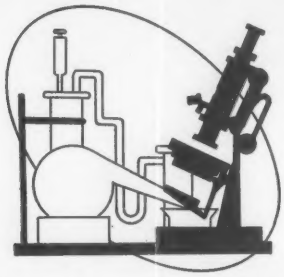

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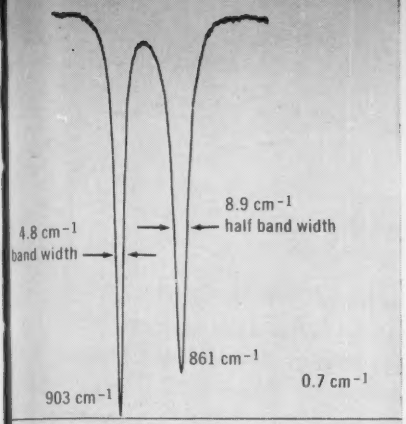
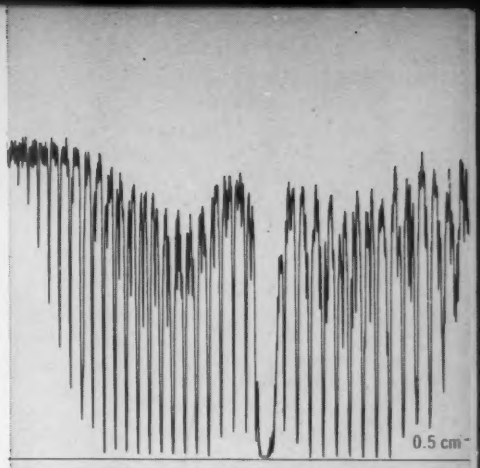
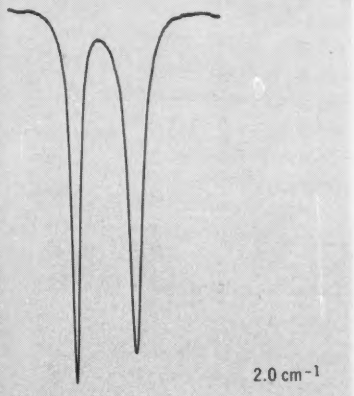
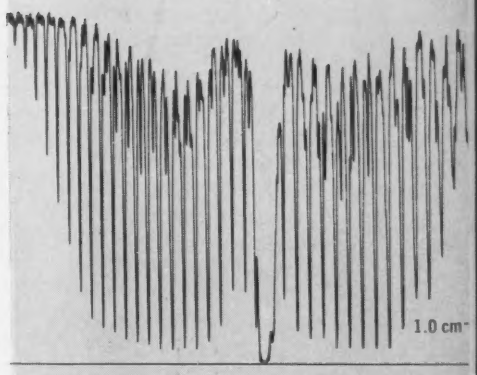


Left, spectrum of a 0.21 mm. thickness sample of spectro-grade cyclohexane demonstrates the importance of high resolution for routine quantitative analysis.

Right, the C-H stretching band of methane illustrates the increased research data obtainable with high resolution spectroscopy.







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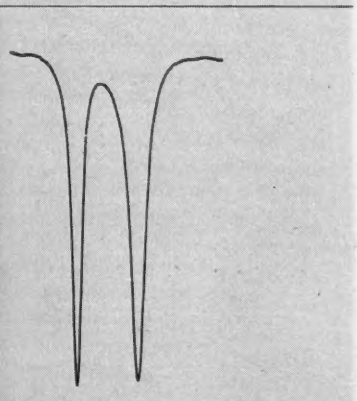

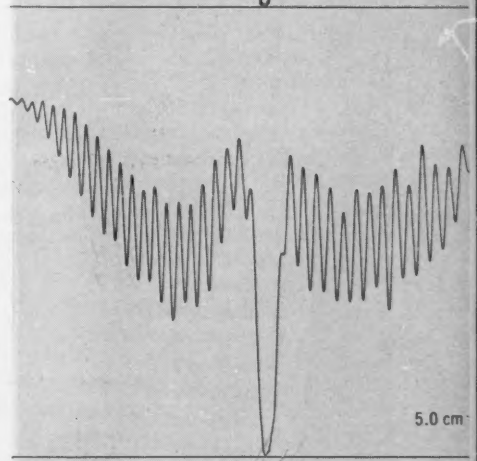

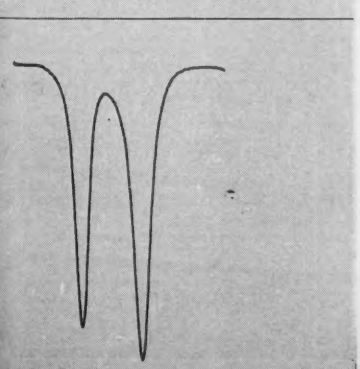

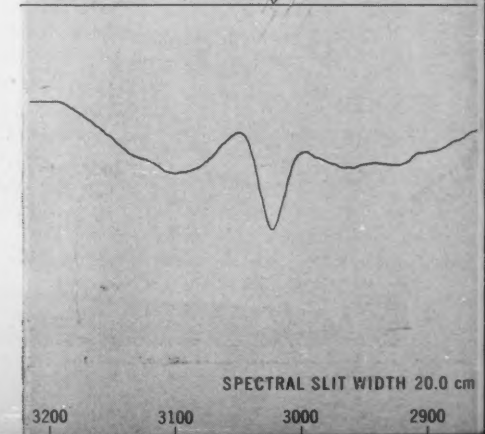

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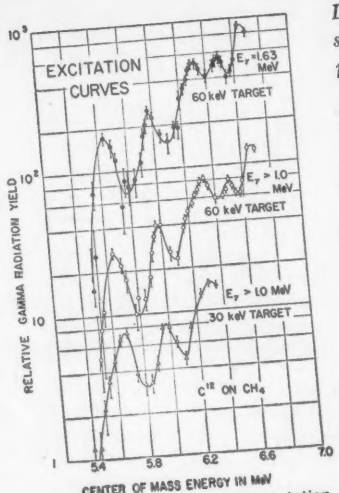

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"Low-Energy" Physics

As we address ourselves to this subject, more elegantly called *nuclear-structure physics,* the reader may conclude we have an axe to grind, and we admit it. We believe a great deal of research remains to be done on light nuclei. There is, for example, time-consuming but rewarding precision nuclear spectroscopy to fill in gaps in existing energy level data, as well as new research related to the conservation of isotopic spin, excitation energies of low excited states and direct interaction mechanisms.

Because much nuclear-structure research can be accomplished with standard Van de Graaffs in the 1-5 Mev energy range, equipped with ion sources for hydrogen, helium or heavy elements, these machines represent ideal research instruments for the university physics laboratory of modest proportions. We are presently compiling information on exactly where machines of moderate cost and energy can make significant contributions in illuminating concepts of nuclear structure and would be happy to discuss this subject with you.

[1] *H. E. Gove, Proceedings of the Second Accelerator Conference, Amsterdam, Oct., 1960 (North Holland Publishing Company, 1961) p. 63.*

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Science for the Citizen

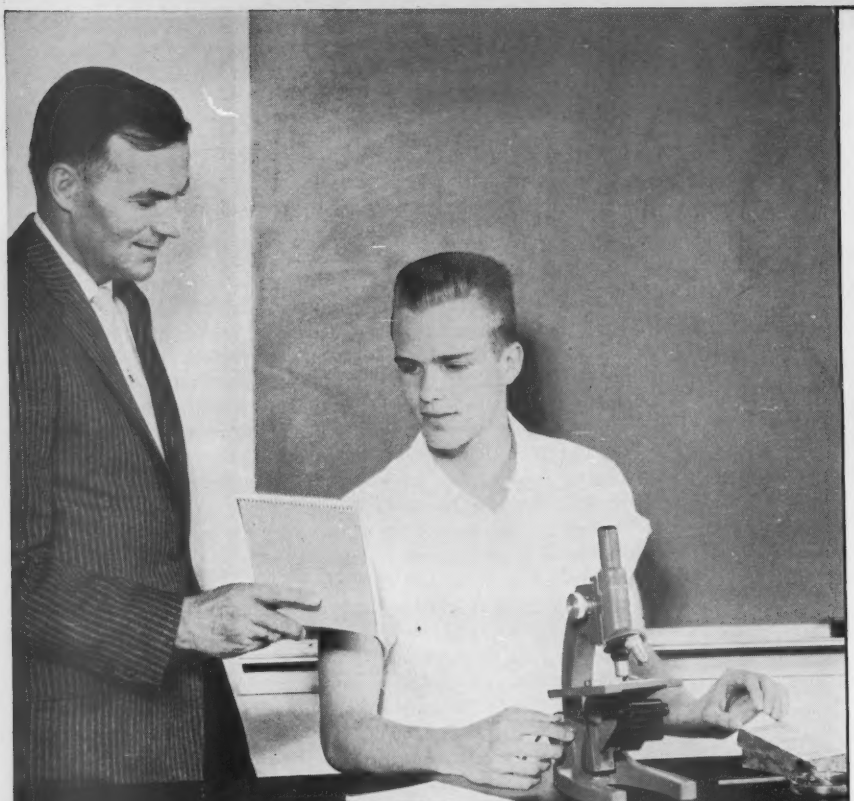
"A democratic citizenry today must understand science in order to have a wide and intelligent democratic participation in many national decisions. Such decisions are being made now. They cannot be postponed for twenty years while we are improving our present educational system so that its products will constitute a significant fraction of the mature voting population. . . . " Thus the President's Science Advisory Committee expressed itself nearly two years ago [*Education for the Age of Science* (24 May 1959)]. What this implies is that if science is to have the kind of support that is essential to its vigorous development, improved ways must be found to increase public understanding of what science and technology can do, of how they are carried out, and of the importance of basic research for its own sake and as the indispensable foundation for an advancing technology.

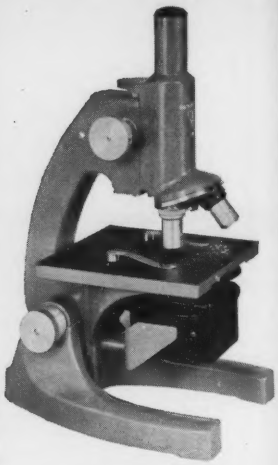
The public to be reached is the general adult population, but what is the most effective way to reach it? In 1959 the National Science Foundation decided that an approach through the mass media—newspapers, magazines, radio, and television—would be the most effective first step, but that this should be an indirect approach, accomplished by helping reporters, science writers, and editors to meet with scientists under conditions that would permit unhurried discussion of scientific problems and a free interchange of ideas.

The problem so far has involved eight 2- to 10-day "workshops" and "seminars" for reporters and science writers and four 1- to 3-day conferences for editors. To judge by the response of the participants, the results justify the effort: the scientists have come to have a more sympathetic understanding of the reporter's problems, and the reporters and science writers have learned more about scientists and their methods of research; the editors have profited in the same way as the writers and have, in addition, come to appreciate the difficulties their reporters face in putting scientific results into readable form for the public.

The enthusiastic response to a small national meeting for editors and scientists held in an informal setting at Marcell, Minnesota, last September led some of the editors who attended to believe that many of their colleagues might welcome a similar experience. Accordingly, the American Society of Newspaper Editors and the American Association for the Advancement of Science decided to cosponsor a seminar on the day prior to the annual ASNE meeting last week, and the National Science Foundation supplied the modest amount of money required to bring the five participating scientists to Washington. The scientists, with one exception, dealt with science itself, not with science and politics or science and culture. Harlow Shapley talked about the outer reaches of space; Francis O. Schmitt, about macromolecules in organisms; Frank Press, about recent developments in geophysics; and Frank A. Brown, Jr., about biological clocks. Warren Weaver, the luncheon speaker, discussed with characteristic breadth and brilliance the reciprocal responsibilities of scientists and the press in informing the public about science.

There is no question about the immediate success of the meeting: the editors relished the rich scientific fare that was provided. But the more important question is: How much of the initial enthusiasm will be translated into action when the editors go home? If they have been convinced that the need to cover events in science is as compelling as the need to cover sports, politics, and the arts, then the long-term impact of the program will be assured.—G.DU.S.





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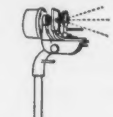

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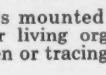

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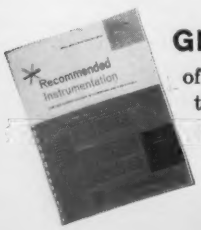

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28 April 1961, Volume 133, Number 3461 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Nest Climate Regulation in Honey Bee Colonies

Honey bees control their domestic environment by methods based on their habit of clustering together.

James Simpson

The individual bees of a colony of honey bees cluster together in their nest position. Within the isolated microclimate of this cluster, vertical wax combs are built and the other domestic activities of the colony proceed. Clustering depends on bees attracting one another by sight, vibration, heat, and the odor of the abdominal scent glands. A minimum of about 50 bees is necessary for a cluster to form at 20°C, though smaller numbers will cluster at lower temperatures (*1, 2*). This clustering behavior differentiates honey bees from bumble bees and social wasps, which either expose their combs to the outside environment or build some sort of protection round them.

Cluster Temperatures

Cluster temperatures in winter were measured before the end of the 18th century, but the first measurements in summer seem to have been made by Lammert in Germany in 1894 and by Gates in Washington, D.C., in 1908 (*3*). The early workers used mercury thermometers. Thermocouples are now generally used, as they are cheaper and smaller and can be used in large numbers. They can be read at a distance, so that the colony is not disturbed, and with suitable amplifying and recording apparatus they give continuous records. Thermocouples have been placed among the bees, in small glass tubes perpendicular to the combs, or in comb foundation, so that the bees build them into the combs (*4–6*).

A compact area of comb underneath the honey that normally occupies the upper and outer regions of the cluster is used for breeding—that is, for the rearing of bee larvae and their metamorphosis to adult bees. The temperature (*7*) in the middle of the brood nest in the summer is normally about 34° to 35°C, with frequent fluctuations of up to 0.5° (*3, 8*). This is usually the hottest part of the colony (apart from the bodies of the bees themselves), though temperatures up to 39°C have been reported where combs are being built (*3, 4*). Temperatures are 3° to 4°C lower, and less constant, in the outer regions of the brood area, and they go down to about 25°C in the broodless part of the cluster (*8*). It has been reported that the brood-nest temperature is steadiest when the cells contain eggs, that it becomes more variable as the larvae grow; and that it may fluctuate by as much as 4°C when the cells are sealed (the pupal stage) (*4*).

The brood nest gets cooler in cold weather but rarely goes below 30°C, though breeding has been recorded at temperatures down to about 25°C. The brood-nest temperature can remain within a range of 5°C while the outside temperature varies from − 40° to +40°C or more, and breeding can occur in the coldest winter weather (*5, 8–11*).

Temperatures as low as 15°C have been recorded at the center of clusters in colonies without brood in winter, but the usual minimum is about 20°C (*8, 12*). Temperatures as low as 4.5°C have been recorded among bees at the periphery of the cluster (*10, 13*), but such conditions cannot last long, for inactive bees go into chill coma at temperatures below 8°C (slight acclimatization to low temperatures can occur), and, though they might then still remain attached to the cluster if undisturbed, they would die in a day or two (*14*). The usual minimum is probably not much below 9° to 10°C (*9, 11, 12, 15*). In effect, the bees keep the center of their cluster at a constant temperature in summer and its periphery above the vital minimum in winter.

Temperature Regulation

The basic reason for the relatively high temperature in the middle of a cluster is that bees, like all fast-moving insects, have a high metabolic rate. An inactive bee at 35°C consumes at least 1 microliter of oxygen per minute. This, relative to body weight, is comparable to the oxygen consumption of a man doing hard manual work (*8, 16*). The body temperature of an isolated resting bee is close to that of its environment because it is small and has a proportionately large cooling surface. When a whole colony of 10,000 to 50,000 bees are clustered together, their heat is conserved, and a substantial difference between cluster and outside temperatures is inevitable (*17*). As the metabolism of fully grown larvae is comparable with that of inactive adults, the brood also produces much heat (*8*). The metabolic rate of bees depends on their activity; a flying or fanning bee produces perhaps 100 times as much heat as a resting one (*8, 18*).

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The body temperature of mammals is controlled by varying the peripheral blood circulation and so adjusting heat loss; by varying the amount of heat produced by muscles; and by cooling from the evaporation of sweat. There is no doubt that bees also have an active cooling system that prevents temperature from going too high, but it is not certain whether temperature is maintained in cold weather by increased heat conservation alone or whether conservation is supplemented by increased heat production.

Control by adjustment of heat loss. It may be readily seen that a bee cluster contracts when the weather is cold and expands when it is warm (Fig. 1). In winter (at temperatures below about 5° to 10°C), the cluster's edge is more sharply defined than at other seasons because the bees at the surface are chilled and so move only sluggishly and cannot leave the cluster. The bees that do leave the colony to fly on sunny but cold days, and those that attack intruders, come from warmer regions inside the cluster. Their movements raise the temperature of the cluster rapidly, and this facilitates their exit (*6, 8, 19*). Bees in winter have reserves of food (up to 40 milligrams) in their honey stomachs (*20*).

Cluster contraction conserves heat by diminishing the area of cooling surface and probably also by diminishing internal convection currents (*10, 21*). However, the cluster becomes filled with combs at its maximum summer volume, and subsequent contraction and the decline in bee population when breeding stops in the autumn leave large parts of the combs projecting in winter (Fig. 2). The heat loss from these "cooling fins" is not diminished by cluster contraction (*4*), and the bees minimize it by keeping the cluster largely on empty combs, which have a much lower conductivity than combs filled with honey (*22*).

Although cluster size and outside temperature are directly correlated, the relationship in winter is not a rigid one. This may show that the bees have a wide temperature tolerance, but any variations in the activity of the bees from nonthermal causes must contribute to the scatter of the correlation (*15*); temperatures at the center of the cluster often fluctuate sharply by as much as 5° to 8°C without any obvious relation to environmental factors (*12*). The sounds produced by a colony after a change in temperature (*23*) show that it takes some time for the bees to settle down to the new conditions.

The immediate cause of cluster contraction is probably simply that bees crowd together when they feel cold. Their thermal preferences have been investigated with a temperature "organ." Bees were put into a chamber of which the bottom was a metal bar, of uniform cross section, heated at one end and cooled at the other so that there was a temperature gradient along it. The preferred temperature region was taken to be the one where the bees came to rest. Very young bees in summer chose the temperature region of about 35°C; older bees preferred a temperature range of from 31° to 36°C. Lower temperatures were preferred in winter. Suitable acclimatization caused the bees to select the region of 28°C (*24*). Other factors also influence preference; in an observation hive where combs with brood had been put in positions away from the center of the cluster, bees were denser and the temperature was higher, usually by 3° to 4°C, over the brood than elsewhere. In contrast, temperatures at the center of the cluster were about as high without brood as with it.

Undisturbed colonies killed with hydrogen cyanide have shown that the winter cluster is divided roughly into an outer shell of closely packed bees and an inner core where the bees have room to move (*11*). It has been calculated that contraction of such a structure in cold weather to maintain a constant temperature at the periphery would increase the temperature at the center (*25*). Such an inverse relationship has sometimes been observed between temperatures at the center of the cluster and daily changes in outside temperature, but not with changes over longer periods (*8*). If a drop in outside temperature does at first produce a rise in temperature in the middle of the cluster, this rise is evidently not maintained, and some more slowly acting mechanism must operate when the low outside temperature persists. This other factor may be an increase in the density of packing of the bees in the outer regions of the cluster. If the contact between the bees' bodies increases as the cluster contracts, the thermal conductivity of the outer layer will increase (*21*) and heat will then pass through more easily, warming the outer bees and cooling the inner ones. A simple explanation of this could be that cold bees on the outside push inwards and hot bees on the inside push outwards, thus compressing the shell of bees till enough heat is transmitted to produce the observed effect. The characteristic head-inwards position of bees at the

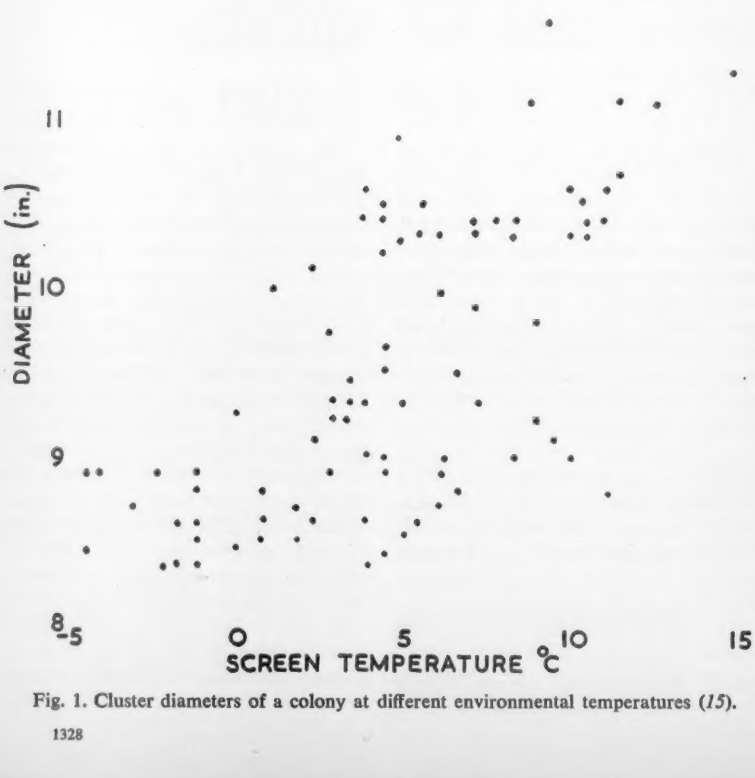

Fig. 1. Cluster diameters of a colony at different environmental temperatures (*15*).

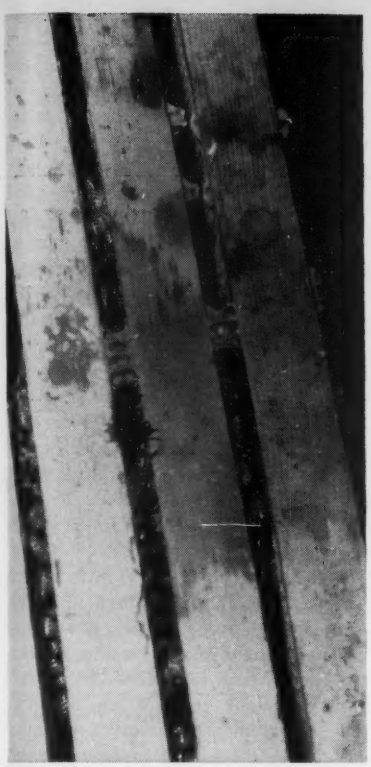

Fig. 2. A small colony of bees in winter. The cluster of bees is closely contracted and covers only a small area of the combs. The outer bees have their heads inward. (The combs are built into movable wooden frames that can be handled by the beekeeper.)

outside of a winter cluster (Fig. 2) supports the idea that they are pushing inwards.

Control by varying heat production. Whereas there is clearly some degree of temperature control through adjustment of heat loss, the evidence for control through adjustment of heat production is less satisfactory, though some people have assumed that the latter is the only method used to counteract low temperatures and have even calculated the amounts of food that colonies should consume at various outside temperatures and in hives with various measured thermal permeabilities (*3*, *4*, *6*).

It is now established that there is a temperature somewhere between 15° and 20°C at which inactive bees, individually exposed, have a maximum metabolic rate. At this temperature their metabolic rate is probably four to five times the rate at 35°C. At lower temperatures the metabolic rate decreases; at the temperature of the cluster surface in winter, the metabolic rate is less than it is at 35°C, and at still lower temperatures it decreases rapidly (*16*). These conclusions, based on respirometer measurements with single bees, are open to the objection that an increase in rate of respiration in cooled bees may result from their struggling to escape to find other bees to cluster with, and that no such increase would be shown by bees in a cluster. However, the respirometer results have been confirmed for the temperature region between 17° and 35°C by measurements of the food consumption and temperatures of groups of bees small enough to have much the same temperature throughout their clusters (*2*) (Figs. 3 and 4).

In winter, the temperature for maximum metabolic rate usually lies in a zone between the center and the periphery of the cluster. Whether this zone moves inwards or outwards or merely stays in the same place when outside temperatures go down, and whether there is any change in the number of bees exposed to the temperature at which metabolic rate is highest, cannot be discovered from existing temperature measurements and is probably not deducible theoretically. It would seem to be to the advantage of the colony that metabolic rate should increase only when the limit of control by heat conservation is reached—that is, at very low outside temperatures or with very small colonies—but the finding that there is a temperature at which individual bees have maximum metabolic rate does not of itself show that this is what happens. The answer can only come from experiments with whole colonies.

Evidence of inverse relationships between cluster temperatures and outside temperatures has been held to provide evidence of control through adjustment of heat production, on the unwarranted assumption that a rise in cluster-center temperature must indicate increased heat production, and vice versa. A second fallacious assumption has been that, because the center of a cluster is hotter than the periphery, the bees at the center must be producing more heat than those further out. So long as the bees in the center are producing any heat at all, they must continually lose heat to the outer bees to remain at a steady temperature, and as heat can only pass from a hotter region to a colder one, the inner bees must be hotter than the outer ones.

Movements of bees seen in the center of a colony in winter, clustered against glass, have been interpreted as special heat-producing activity to counteract low outside temperatures (*6*), but similar movements can be seen in a heated observation hive in summer, when extra heat production would not be needed. However, failure to see special heat-producing movements does not prove there is no mechanism producing additional heat, because heat could be generated by opposing muscular tensions without any visible movement except that of more frequent breathing.

Records of the amount of food consumed by colonies in winter (estimated by loss in weight) usually fail to show any definite correlation with outside temperature because other factors influence weight loss. The few records that do appear to be significant (*10*) suggest that low temperatures decrease rather than increase food consumption.

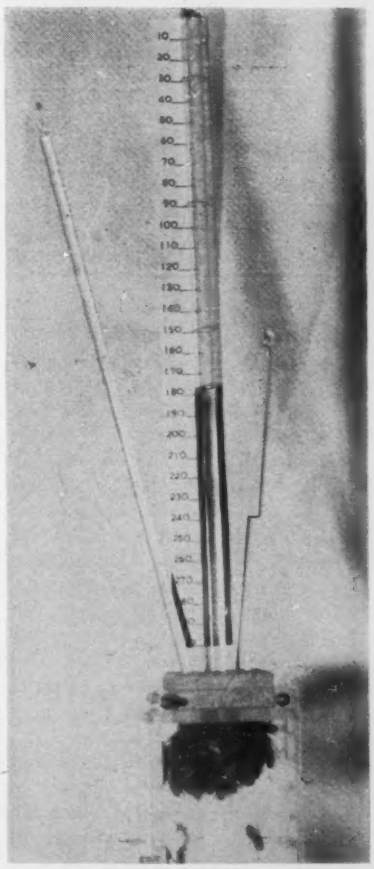

Fig. 3. A method of measuring the food consumption of a small cluster of bees (*2*). The feeder in the center contains sugar syrup; that on the right, water. The thermometer measures the temperature of the cluster. The whole apparatus is exposed to a series of environmental temperatures.

A measurement of the carbon dioxide evolved by a whole colony at different temperatures led to a similar conclusion. Comparisons of the winter weight losses of colonies in insulated hives, or in hives in bee houses or cellars, with losses of colonies in single-walled hives outside have given contradictory results. As this kind of protection from cold also diminishes temperature fluctuations, the protected colonies may eat less because they are less disturbed (*8*).

Colonies in North America, whether in insulated hives or not, seem to require at least four times as much winter food as colonies in Germany (*11, 26*), but this is probably because the strains of bee and the methods of management preferred in America produce larger colonies and much more autumn and winter brood.

The available evidence (*10, 12, 27*) seems to show that the difference between the temperature outside a hive and the temperature inside it, but outside the cluster of bees, is greatest when outside temperatures are low. If this is so, it is probably the only current evidence of increased metabolic rate at low temperatures for whole colonies.

Active Cooling

When outside temperatures approach levels necessary for domestic activity in the colony, the bees do not need to cluster to conserve heat, but they cannot spread apart indefinitely, as certain minimum densities are required for feeding the brood, building the comb, storing honey, and so on. These aggregations could cause excessively high temperatures if cluster expansion were the only means of preventing overheating. In fact, colonies have been subjected experimentally to temperatures as high as 50°C without their cluster temperatures exceeding about 38°C, so long as their cooling mechanism could function (*5, 8*).

Excessively high temperatures are prevented by rapid exchange of air between the cluster and the outside, by chains of bees fanning with their wings, and by watery material evaporated on the bees' mouth parts and on comb surfaces (*5, 28, 29*). Nectar to be concentrated is exposed in the same way (*8*). Water evaporation is a response to high temperature and not to low relative humidity. Water for cooling is collected by foraging bees. A high sugar concentration in the food that is constantly being passed from bee to bee in the colony stimulates the collection of water. Thus, collection of water is induced by water shortage resulting from evaporation and not directly by high temperature. When a colony is supplied with dyed water, the material exposed for evaporation is colored, so it must come, at least in part, from the bees' honey stomachs. Water in the honey stomach probably always contains some sugar, as bees cannot live long without food. There is no clear demarcation between water collection and evaporation and nectar collection and concentration. Colonies that are overheated or have been unable to collect water for several days prefer dilute to concentrated nectar (*29*). Colonies given colored water produce colored honey.

Fanning to cool or ventilate the cluster (ventilation fanning) must be distinguished from the kind of fanning in which the abdominal scent glands are open, which is part of the mechanism of colony cohesion and orientation (communicative fanning). German writers call the former *fächeln* and the latter *sterzeln*. Rather surprisingly, it is always communicative fanning that is induced by blowing smoke into a colony.

In ventilation fanning, *Apis mellifera* usually drives air away from the cluster; *A. cerana* drives air towards it (*30*). In an observation hive, chains of bees all fanning in the same direction seem to form only outside the cluster. Bees fanning inside the cluster seem to do so more or less at random; sometimes two bees can be seen fanning head to head in opposite directions. Presumably such bees accelerate the escape of gases produced in the cluster simply by dispersing local accumulations.

Ventilation fanning has been induced experimentally by overheating colonies (*5, 8, 28*). It is also much in evidence when nectar is being concentrated, when the stimulus is probably high humidity. High temperature induces exposure of water to evaporation, so it may cause fanning indirectly.

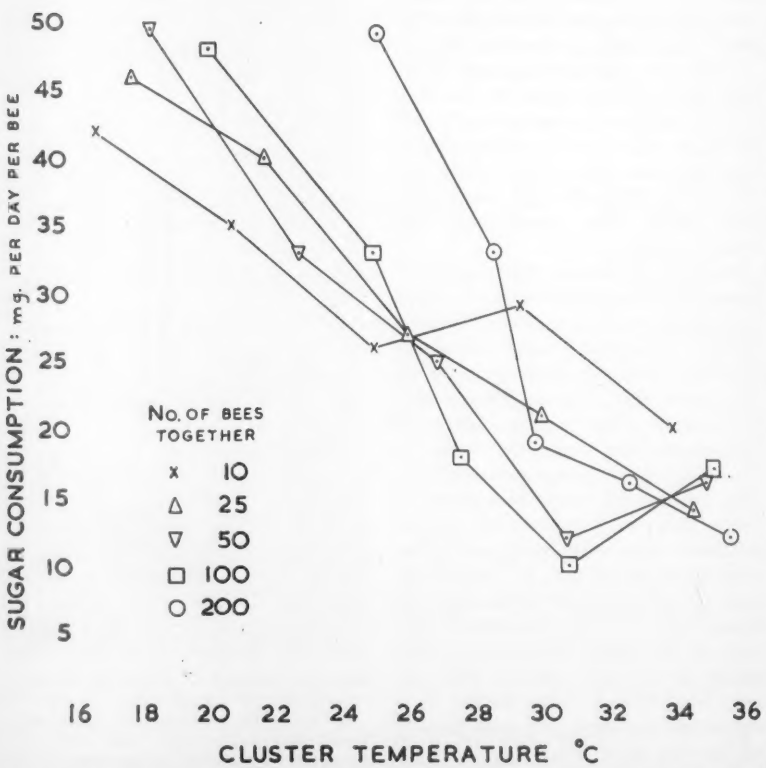

Fig. 4. Food consumption of bees at different temperatures, as measured by the method shown in Fig. 3.

Cluster Humidity

Humidity in a hive but outside the cluster of bees can be measured with an ordinary hair hygrograph (*8*) or psychrometer (*4*), but within the cluster, particularly in winter, it is measurable

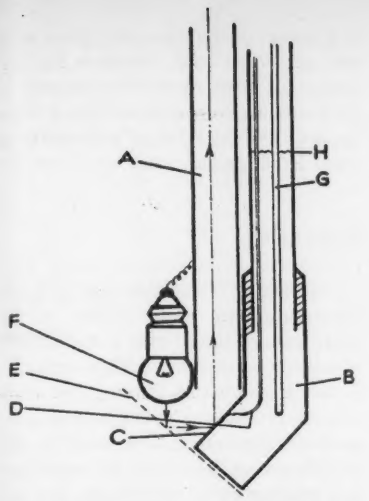

Fig. 5. Apparatus for measuring the dew point in a cluster of bees (*9*). Only a portion of the glass tubes is shown; their total length is about 23 centimeters. *A*, viewing tube; *B*, metal thimble cemented to glass tube with Polythene; *D*, thermocouple soldered to the back of a metal mirror *C*; *E*, part of a perforated zinc screen to exclude bees and provide the image seen in the mirror when no dew is present; *F*, light bulb; *G*, tube for air to vaporize ether; *H*, ether level before evaporation. [Actual size]

only with apparatus that takes up little space and gives an accurate reading with a small volume of air. A microdewpoint apparatus with the mirror surface viewed through a tube leading out of the cluster (see Fig. 5), a miniature hair hygrograph (*31*), and a thermoelectric aspiration psychrometer that uses only 30 milliliters of air (*5*) have been used.

In summer, at times when little water or nectar is being evaporated, the partial pressure of water vapor in the cluster may be only 3 to 4 mm-Hg above that of the outside air and may vary by less than 1 mm in different parts of the cluster. Under these circumstances the relative humidity varies with the temperature and is lowest in the brood area, where 40 to 50 percent has been recorded. At the other extreme, brood-nest relative humidities up to 70 percent have been recorded in an overheated colony where water was exposed to evaporation, and humidities up to 100 percent have been recorded in such a colony when the only aperture was a single bottom entrance (*4*, *5*). Absolute humidity outside is positively correlated with temperature and is necessarily low in winter. Colonies kept in heated rooms in cold winter weather can have abnormally low relative humidities in the cluster (20 percent or less), and desiccation of larvae may prevent them from rearing brood.

In a colony kept outside in winter, the tight cluster hinders the escape of water vapor. An average partial pressure of 15 mm in the middle of the cluster has been recorded when the average outside was 7 mm. Cluster temperatures ranged from 20° to 30°C, giving relative humidities from about 85 to 50 percent. Brood reared in winter is protected from desiccation by dense clustering and low brood-nest temperature. The absolute humidity at the center of a winter cluster is well above the saturation level at the temperature of the cluster surface, but condensation rarely occurs in or near the cluster (*9*). Among the bees at the periphery of the cluster, partial pressures of water vapor seem to be close to those outside. Measurements (*31*) have shown 5 to 10 mm. Evidently there is a gradient of absolute humidity somewhere between the center of the cluster and the surface, and water vapor escapes by diffusion rather than by a through current of air. The fanning often heard in a winter cluster presumably keeps the absolute humidity fairly uniform throughout the loose central region, making conditions there like those in a summer cluster.

Cluster humidity is physiologically important to adult bees in winter as well as to brood at all times. Honey bees do not normally discharge their rectal contents in the nest, and when they are confined to the cluster by cold, they cannot obtain water should they require it, or discharge outside any surplus they accumulate. Forced discharge of rectal contents in the nest ("bee dysentery") can kill a colony. Surviving long periods of confinement, therefore, depends on a balance between water production from metabolism of food and water loss by evaporation from the bees' bodies. The balance is made possible by the dryness (15 to 20 percent moisture) of the winter food (honey).

Experiments with bees in a humidity "organ" analogous to the temperature organ showed some response to variation in humidity but no definite preferences (*32*). Apart from possible fanning at high humidities there is little evidence that a colony actively controls its humidity, though tight clustering in cold weather and water evaporation in hot weather tend to stabilize it.

Carbon Dioxide and Oxygen

The carbon dioxide concentration in samples of air withdrawn (through tubing of 1-millimeter bore) from various points in a cluster in summer has been estimated (*28*). The average was about 0.7 percent (by volume), and the maximum, 1.0 percent (2.3 percent in an observation hive). Up to 3 percent has been found (*33*) in summer and up to 6 percent in winter (*34*). A deduction from humidity measurements (*9*) and the proportion of carbon dioxide to water vapor produced by metabolism gives about 4 percent in winter, on the assumption that both gases leave the cluster by diffusion. Strong ventilation fanning has been obtained by artificially raising the carbon dioxide concentration to about 3.5 percent in summer, but the significance of this is doubtful as the fanning continued for some time after the carbon-dioxide concentration had returned to the original level (*28*, *33*). The causes of ventilation fanning need to be investigated further.

Control of carbon dioxide or oxygen concentration may be unnecessary under natural conditions. Isolated bees do not visibly react to carbon dioxide concentrations of less than 10 percent or to oxygen concentrations of more than 7 percent (*35*).

Influence of Nest Cavity on Cluster Environment

Apis dorsata and *Apis florea*, the species of honey bee that nest entirely in the open and build a single comb suspended from a branch of a tree or other suitable overhanging surface, are confined to the tropics. *Apis cerana* of Asia and *Apis mellifera* of Europe and Africa, which are used by beekeepers and have subspecies adapted to temperate regions, build numerous parallel combs and normally nest in an enclosed space such as a hollow tree, a rock cavity, or some structure made by man. After swarming, however, they usually cluster temporarily on a branch of a tree and occasionally stay there and build combs. In favorable conditions, such a colony can live for some time; if protected from rain and predators, it might even survive a winter (*11*).

A colony in a cavity is sheltered from rain and direct solar radiation and needs only to guard the openings of the cavity to keep out predators and robber

bees. Provision for security against robbers facilitates extensive storage of honey, as the cluster can move off filled areas of comb and extend the combs elsewhere. Ventilation of the colony is influenced by the nature of the cavity, the number and position of its openings, and the amount of space the cluster occupies. In a cavity with both upper and lower openings (for example, a hive with a bottom entrance and a ventilation hole at the top), air may pass upward by convection, or downward when bees are fanning at the bottom entrance. Air flows of 0.17 liter per second, by convection, and of 0.40 to 1.00 liter per second, by fanning, have been observed through such a hive (*28*). Air can flow through the cavity more easily when there is space between the cluster and the walls than when it must all go through the cluster. Some exchange by convection can occur when there is only a top aperture but not when there is only a bottom one. With a single aperture, wind and fanning can only increase ventilation by causing turbulence in the hive; air entering at one part of the entrance to replace air sucked out by fanning at another must take the shortest distance between the points of entry and exit (*36*). A fall in pressure of 2 mm of paraffin has been recorded when bees were fanning over the full width of the bottom entrance of an otherwise tightly sealed hive (*28*). Active ventilation of a cavity with a single entrance can be produced by bees fanning inside. In an observation hive with a long glass-covered entrance tunnel, chains of bees fanning round the inside of the hive outside the cluster, and parallel chains fanning in opposite directions in the entrance tunnel, have been seen.

The amount of thermal protection provided by the walls of the nest cavity has been much debated. Close contact with walls of low thermal conductivity may decrease cooling from part of the cluster surface and so make possible the formation of a larger cluster; also, for a given thickness of wall, the larger the cavity the larger its cooling surface must be. Thus, in spring, when brood rearing is limited by cluster size, breeding may be more rapid in a small cavity. One observer (*4*) has reported frequent temperature fluctuations of up to 6°C in the brood nest of a colony with much unoccupied space in its hive, but nobody else seems to have noticed anything of the kind; probably a colony can control its cluster temperature effectively in a cavity of any size.

It has been said (*11*) that in winter the temperature inside a hive but outside the cluster of bees is close to the temperature outside the hive (except after sudden changes in outside temperature). This may well be true if the hive entrance is big enough, and particularly if there is also a ventilator or an additional entrance at the top, but with small entrances and heavy insulation, differences as great as 25°C have been observed at very low outside temperatures (*8, 10*). Insulation in combination with entrance restriction can probably raise hive temperatures enough to have a substantial effect on heat loss from the cool outside surface of the cluster. There is some evidence (*37*) that, in very cold winter climates, the number of colonies that die because the bees cannot move to fresh food after emptying the combs within their reach is decreased by hive insulation.

Thermal protection may have disadvantages, however. By retarding penetration of heat during a sudden rise in outside temperature (*38*), it increases the likelihood that moisture will condense in the nest cavity and decreases the chance that the bees will get warm enough to fly to discharge their rectal contents. Both of these effects promote "dysentery," and condensation produces mouldy combs (*39*). However, as the bees produce about 5 times the amount of heat required to vaporize the amount of water they put out, under steady outside conditions condensation is not increased by restricting ventilation, so long as the proportion of heat passing through the walls of the nest cavity is negligible. Thus, insulation diminishes the amount of ventilation necessary or effective for decreasing condensation (*4*). The relative importance of these two ways in which thermal protection can influence the water metabolism of a colony seems not to have been assessed.

Where winters are cold, the advantages of thermal protection may outweigh the disadvantages, particularly as a moderate rise from a very low temperature can give little increase in absolute humidity or opportunity for flight. Where winters are mild, easy entry for heat may be more important. Experiments (*39*) indicate that when insulation is minimal very free ventilation is necessary to avoid condensation. Bees indigenous to the mountainous regions of the Caucasus, where winters are very cold, contract the entrances of their nests with propolis in the autumn, and bees of western Europe do not. This may be an adaptation to climatic conditions.

Conclusion

Colonies of honey bees can keep the temperature of their cluster within fairly narrow limits over a wide range of outside temperatures. High temperatures are avoided by fanning and evaporation of water. Control at low temperatures depends at least partly on the adjustment of heat loss by expansion and contraction of the cluster. The extent, if any, to which heat production is increased is still uncertain.

Little is known about whether the humidity and carbon dioxide content of the atmosphere of the cluster are controlled independently of temperature. The mechanism of temperature control also largely stabilizes humidity. The stimuli causing ventilation fanning need to be investigated further.

A nest cavity with walls of low thermal permeability and restricted ventilation may give a colony useful protection at very low winter temperatures, but this thermal protection also has disadvantages. In mild winters, poor ventilation can be dangerous.

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Data Processing by Optical Coincidence

This unconventional use of punched cards provides a flexible and rapid means for hand tabulation.

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The task of evaluating data is common to all sciences. Sometimes this problem can be readily solved, but when a study embraces more than a few variables, examination of the interrelationships between them poses technical difficulties. Even though we are working in an age of high-speed computers, there is a need for further development of readily available processing methods that will permit flexibility in analysis. Such flexibility facilitates the development, reformulation, and rapid follow-up of hypotheses. The present article offers one such technique, a method for storing data and obtaining cross tabulations. Among its specific advantages are the following: (i) convenience—there is no reliance on complex and bulky machines typical of central-office installations; time-consuming communications with processing personnel and the wait for return of data are eliminated; (ii) flexibility—the storage provides the equivalent of an IBM card with an infinite number of columns, and in subsequent processing, complex multivariate tables can be constructed with ease; (iii) speed—the method is faster than other hand-operated procedures for data tabulation; (iv) accuracy—simplicity of operation permits easy and frequent checks; (v) economy—economy of effort has already been mentioned; the economy of the technique in dollars and cents is equally striking. For example, in one application of this procedure, an outlay of approximately one dollar would enable the research worker to set up shop.

The method departs from procedures conventionally employed. Ordinarily the *individual* or the *case* serves as the basic conceptual entity—the central unit about which observations are collected. In the behavioral sciences, for example, we ask questions of the individual, we measure his responses, we observe his behavior (*1*). Having collected the data on a case-by-case basis, we then typically store it in the same fashion. The interview schedule, the case file, or other data constitute a record that may be preserved intact or may be evaluated in a variety of ways. When the research worker begins to summarize data on a considerable number of persons, he may for purposes of data processing set up a code sheet for each person included in a study, and may enter suitably coded information on each individual on one or more punched cards. Thus, in conventional procedures the unit for data collection, the individual, remains the unit for data storage.

The alternative method, with which we have been experimenting, employs as a basic principle one that has been profitably used in some bibliographic and indexing work in recent years (*2*). As used in indexing, the system inverts conventional procedures by using conceptual categories, rather than documents, as the units for storage. All documents are assigned code numbers, and concept cards (as opposed to document cards) are used for recording, in writing or by punched position, all documents pertaining to the concepts in question. Thus, to identify all documents which contain information in all of several specific concept areas, the appropriate concept cards are selected and the document numbers that appear on all the cards selected are obtained (*3*).

In applying this system to data analysis we use punched cards as a medium for storage, but again the system differs from conventional procedures, for the storage system is organized in terms of coded characteristics ("male," "female," "only child," "first born," "later born," and so on) rather than of individuals. There is a card for each characteristic, and each individual is assigned the same position on every card. If a given characteristic is associated with a particular individual, a punch is made in his specified position on the card for that characteristic. To illustrate, Card *A* in Fig. 1 has

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numbered positions for 28 individuals. Punches have been made in 12 of these positions (including position number 21 which identifies Charlie Brown)—an indication that the characteristic, "male," is associated with each of the 12 individuals. Similarly, card *B* shows that nine of the 28 individuals are in the "only child" category. (Since Charlie Brown is not an only child, no punch has been made in position 21.) To determine the number of males who are only children, one superimposes card *A* on card *B*, as shown in Fig. 1 (bottom). Only in cases in which the individual's position has been punched on *both* cards (cards for "male" and "only child") will perforations coincide when card *A* is superimposed on card *B*. The number of such instances of coincidence can then be determined visually. In Fig. 1, there are five perforations common to the two cards; this number represents the total for one cell of the 2- by 3-cell table which relates sex and birth order. Completion of a tabular analysis relating these two variables (or "dimensions") then becomes a matter of selecting all of the category cards for the two dimensions and systematically pairing them, successively superimposing each category card for one dimension on every category card of the other, and counting the number of perforations common to each such pair. In this fashion the frequencies for each of the six cells of the table relating sex and birth order may be obtained.

These are the essential elements of the system. The more detailed exposition that follows describes procedural details that have proven effective in our exploration of the possibilities of this approach.

Input

Code sheets. Storage of data is accomplished by punching holes on category cards. For ease of processing it is convenient to record data on code sheets prior to punching. Since the data are about individuals, we code on an individual-by-individual basis. But the organization of the code sheets discussed below facilitates subsequent punching on a dimension-by-dimension basis.

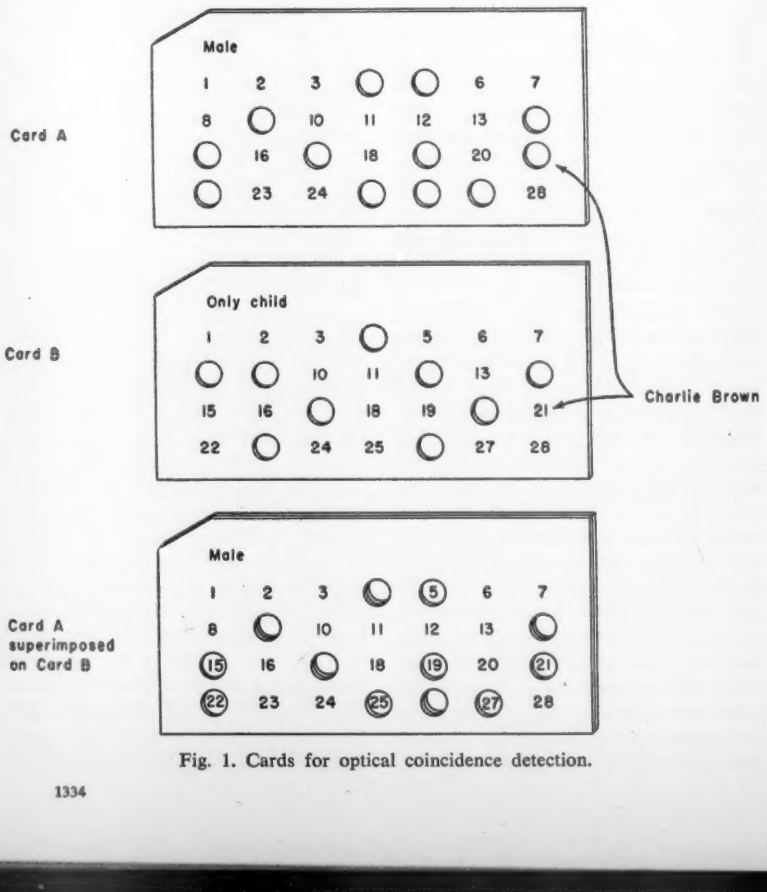

Fig. 1. Cards for optical coincidence detection.

The code sheet best adapted for this system may be conceived of as a coordinate system, in which each one of *l* rows identifies an individual for whom data are recorded, and each one of *k* columns identifies a dimension (variable or attribute) on which data are obtained. Figure 2 shows a fragment of such a code sheet. In the left-hand column are the case identification numbers, usually (but not necessarily) sequentially assigned. The column headings, *A1*, *B1*, *C1*, and so on, are the code labels for specific dimensions to be recorded.

Typically, entry of information on the code sheet proceeds in a case-by-case fashion. Thus, the appropriately coded information on the person to whom code number 1 has been assigned is entered in row 1: His code on dimension *A1* is recorded in row 1, column *A1*; similarly, the code for this individual for dimension *B1* would be entered in row 1, column *B1*; and so on. And in the same fashion the information on the second individual is entered in the second row; information on the *i*-th individual, in the *i*-th row.

Unless one is working with a very small sample and a restricted number of variables, the number of individuals for whom data are to be recorded will exceed the number of rows on a single tabular sheet, and the number of dimensions with which the investigator is concerned will be greater than the number of columns. It is, however, a simple matter to "extend" the size of the coding matrix by adding additional sheets, which can be conveniently and compactly assembled in a looseleaf binder.

Four advantages of this procedure are worth noting. (i) Even before cards are punched, a visual inspection of the appropriate columns of the coordinate code sheets can provide a quick initial impression of the nature of the relationship between any two variables. (ii) Use of a coordinate system for recording data can effect an appreciable reduction in storage space over that required by a procedure in which a single code sheet is used for each individual. (For example, on a coordinate code sheet consisting of 30 rows and 20 dimension columns plus a case-identification column, one could record 80 different types of information on 300 individuals on a total of 40 sheets. This is in marked contrast to the 300 code sheets that would be required if a code

sheet were used for each individual.) (iii) Coordinate code sheets have a flexibility that is not found in individual code sheets. The same coordinate sheets that permit subsequent storage of punched-card data according to the dimension-by-dimension pattern described here may, if they are reordered, readily be used in conventional case-by-case storage of punched-card data. (iv) Coodinate code sheets constitute an "open system." Not only additional individuals but also additional variables may easily be added by the research worker at any stage of the research process.

Punching equipment. Once the data have been recorded on code sheets, the process of storing information on the cards may begin. The system requires a means for precisely locating punching positions and a convenient method for punching.

The stub-pencil researcher can assemble all the materials he needs for punching at a relatively low cost. To set up this procedure on the least expensive basis possible, one would need to purchase a simple conductor's punch and a number of file cards of an appropriate size. A 5- by 8-inch file card can readily handle a couple of hundred cases. Such file cards do not at the outset have precisely placed punching positions defined on their surface. Two ways of meeting this problem are suggested. One might print (by accurate stencil duplication or other means) a suitable grid for punching on each card. Alternatively, one might identify and punch every position on a master card and then use this card as a template in subsequent punching.

More expensive, but at the same time more convenient and able to accommodate a larger number of cases, are cards and punches devised for conventional data-processing applications. Though these were designed for use with typical individual-by-individual input, they can be effectively employed in the dimension-by-dimension application of the techniques under discussion. The Sperry-Rand Corporation markets a special hand punch and a card for use in connection with it. This card could accommodate up to 540 cases. Other inexpensive commercial punching equipment consists of the IBM Port-A-Punch board and the cards used with it. The card, identical in size to the conventional IBM card, has 480 punching positions prescored on it. It

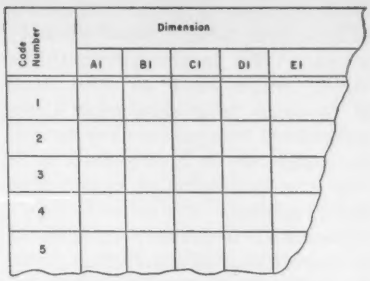

Fig. 2. Coordinate code sheet.

is slipped into the punching board, and then a stylus, resembling a mechanical pencil, is used to push out the bits of cardboard and make the holes.

Principles of data storage. No matter what the exact nature of the card and punching equipment, the basic principles of information storage by this method remain the same. Each card has a fixed number of positions on it. A single specified position is assigned to each individual for whom data have been obtained. The location of the position assigned to an individual on one card is identical to the postion assigned to him on every other card (*4*). Thus, if in the fourth column of a card the fifth punching position is assigned to the individual who has the code number 45, the fifth punching positions in the fourth columns of *all* other cards in the deck similarly "belong" to that individual—whether they are punched or not. (A procedure is described below that permits one to use this feature of fixed position to considerable advantage in subsequent data analysis.)

Punching of a given dimension requires as many cards as there are coded categories in the dimension. For example, in a study of child rearing, the dimension "sex of oldest child" (if no twins are included in the sample) would require two cards—"male" and "female"; the dimension "number of children in family" might be handled by four cards—"one child," "two children," "three children," and "four or more children." Each card is labeled with designations of both the dimension and the specific category. These labels may, of course, either be recorded in full or be written in suitably encoded form. The latter method has the dual advantage of being more rapid and of simplifying subsequent filing.

In practice, several alternative procedures may be used to locate and name each punching position: (i) numbers may be printed on the cards to identify the positions; (ii) columnar and row designations may be printed on the surface of each card, and the position may be identified by a grid coordinate reading; (iii) one card may be set up as a template with labeled positions as a guide in punching.

Card punching. The punching operation is a simple one. The category cards for a given dimension are set up, and punching on the first-category card proceeds. The punch operator reads down the column containing code entries for the dimension in question, and each time the first category appears he punches the category card in the position assigned to the case number associated with the particular row on the code sheet in which the entry occurs. The punching of each additional category card necessitates a rescanning of the appropriate dimension column of the code sheet (*5*).

An alternative method that readily suggests itself, of course, is one in which the operator follows down a column only once and, shifting back and forth between category cards, punches the coded entry for each individual in the natural sequence of progression down the column. In our own experiments with input procedures we have tended to reject this method for three principal reasons: It does not permit positive reliability checks as readily as the first method; in actual operation it takes more time than the first method; and it does not facilitate combining of categories as an integral part of initial punching (a procedure described below).

For a variety of reasons one might wish to combine categories in certain subsequent analyses. For example, such pooling might be considered when the frequency of cases in one or more categories is small, or when utilization of some scale analysis procedures might be facilitated by such combination. With "optical coincidence" procedures, combining categories is a process that can be incorporated in the initial punching routine with minimum effort. In addition to the specific category cards, one sets up combination cards. To return to a previous example, that of punching for the dimension "number of children in family," we might, for some phases of our analysis, want to reduce this dimension to two cate-

gories: "one child" and "two or more children." The latter category would then be indicated on an additional combination card. Then, in the punching operation the combination card would be placed in position behind the "two children" card while that category was punched. Next it would be aligned for punching with the "three children" card and finally with the "four or more children" card. Combining categories in this fashion is an economical procedure; in this case, for instance, we obtain four cards for the punching price of three.

If categories of a coded dimension are mutually exclusive, one may build in a positive and complete check of reliability of the punching operation. This is a logical extension of the process of combining categories. Required for such a check are a pre-punched master card (a card in which holes have been punched in each position for every individual actually included in the study) and an initially unpunched "total-check" card. The total-check card is aligned behind the first category card for the given dimension, and punching is accomplished in the same fashion as in combining categories. On completion of first-category punching, the total-check card is placed behind the second category card and punching continues. After data for all categories have been punched in this fashion, the check card should then contain perforations in every location assigned to an individual included in the study.

One may now make two checks. (i) The total-check card is superimposed on the pre-punched master card. If, on inspection, all perforations in the two cards are found to correspond, then no case has been omitted in punching. (ii) Specific category cards are then paired with one another, and in this case coincidence of perforations indicates erroneous punching. Any errors detected in this fashion can be corrected by reinserting one of the punched-out bits or by otherwise masking the erroneous punch. After checks have been completed, a count of all perforations in each category card is recorded on its surface. This recorded information is then always available as a check on marginal frequencies in subsequent tabulations. When appropriate checks have been made, the cards, identified by dimension and category, may be filed until they are needed for subsequent tabulations (*6*).

Output

To obtain tabular information by means of the system described is a simple process which we have found to be more rapid than other hand-manipulated procedures. Further, in our experience, we have found it to be frequently preferable to central-office data processing.

"Readout" is always accomplished by superimposing appropriate cards. No special equipment is needed, but a card alignment board is both a convenience and a timesaver. It makes precise superimposition of cards an automatic process. The alignment board may consist merely of a piece of heavy cardboard or hardboard, slightly larger than the card, and of two card-alignment strips, one located at the bottom edge, the other at one side of the board. A board with a dark surface is desirable for contrast with the light cards. Or one could construct a more elaborate viewbox with a light shining through a translucent panel on which the cards would be placed. If the IBM Port-A-Punch is used for input, the board also serves adequately for readout purposes.

Obtaining information on "straight runs" (simple marginal frequencies for all variables) requires almost literally no work at all. The procedure for storing information essentially amounts to a pre-sorting of all cases for every dimension for which data are recorded. Hence, the recorded frequencies of perforations on the cards for the various categories of the dimensions in question provide the desired information on marginal frequencies. From an inspection of such frequencies the research worker may, on occasion, decide that for subsequent analyses certain data categories for a given dimension should be combined. This can be done by superimposing, in turn, on a combination card each category card pertaining to the new pooled category and making corresponding perforations on the combination card.

Simple cross tabulations of two dimensions are easily and quickly effected. First one sets up the format of the table on tabular paper and selects from the file all category cards for the two dimensions that are being related to one another. One then superimposes the first-category card of the first dimension on the first-category card of the second dimension and counts the number of instances in which the perforations on the two cards coincide. This count is then entered in the appropriate cell of the table. The first-category card of the first dimension is next paired with cards for each other category of the second dimension, and these counts are recorded in the appropriate cells. The table is completed by following the same procedure with the succeeding categories of the first dimension. After entries for all the cells of the table have been obtained in this way, column and row marginal totals are obtained, and these totals for each category are checked against the totals recorded on each category card of the two dimensions employed in the table. Illustrative of the speed with which such cross tabulations can be made is the fact that the total time required to count and record the information in a 5- by 5-cell table for relating general sociometric data on 264 children at two different points in time was less than four minutes; all of the "equipment" needed for this tabular operation can be readily placed in one's coat pocket.

Complex cross tabulations with three or more variables are simply the logical extension of the two-dimensional tabulations described above. One sets up the desired tabular format on paper, selects the necessary dimension cards from the file, stacks the category cards defining a particular cell together, and then counts the perforations common to the several cards. (In a three-dimensional table, for example, cards are stacked together three at a time, one category card from each dimension.) One similarly determines every other cell entry for the table by stacking the appropriate cards and then making a count of the number of coinciding perforations. After entries have been made in all the cells, the routine marginal check can quickly be made. It is worth noting that in a 3- by 3- by 3- by 3-cell table—that is, an 81-cell table—only 12 different cards are used in the total cross tabulation, and the number of separate "stacks" of cards used by the tabulator is much smaller than would be the case with any conventional method of hand sorting.

In addition, by observing the coincidence of perforations in the several superimposed cards one may directly identify, from position numbers, individuals with a particular combination of characteristics. Such identification can prove useful in deviant case analysis.

Short Cuts and Timesavers

In our explorations of the usefulness of the procedures described above, two techniques have proven to be effective timesavers in the data-analysis process: (i) the use of code numbers for individuals as a means of preclassifying them with respect to one or more variables that will play a major role in subsequent analyses, and (ii) a technique for obtaining data for several tables "simultaneously" in a way that reduces the amount of card manipulation necessary.

Preclassification by position. In data processing by optical coincidence each individual is assigned the same position on each card. The assignment of such positions could be based on any one of several schemes. For example, positions could be assigned alphabetically, or in numerical sequence according to the chronological order in which data on individuals were obtained, or in a completely random fashion. An alternative procedure, in which designation of position is deliberately related to relevant research variables, can materially speed the subsequent tabulation process.

If the investigator plans to include one or two fundamental variables in a large number of his tabulations, he may designate specific areas of the card for each category of these variables. This may be described as preclassification by position. Thus, if one were primarily interested in examining the relation between maternal age and a series of other variables, the preclassification procedure could be as follows. (i) Determine the total number of different maternal age classifications to be used (for example, "under 20," "20–24," "25–29," "30–34," "35–39," "40 and over"). (ii) Assign to each of these categories a *region* of the card. For example, one might simply divide the card into six fields, each field consisting of a sufficient number of columns to permit the assignment of one position to each individual included in the sample who falls in that age field. (iii) Assign code numbers in such a way that a given sequence of code numbers applies to a given field, identifying a particular age classification. (iv) Proceed with input procedures as described above. The information stored on each category card would thus be automatically preclassified by age.

The advantage of this procedure becomes readily apparent when we consider output. Let us assume that we want to study the way in which responses to a series of questions about child development are related to maternal age. If we break a five-category classification of "mother's affectional warmth toward child" according to "age of mother," our end product is a 5- by 6-cell table. If we use the optical-coincidence procedure *without* preclassification we have to manipulate 11 cards (six for age and five for affectional warmth) in 30 separate pairings. In marked contrast to this, however, the employment of preclassification coding procedures on one dimension, "age of mother," permits us to read off entries for the table directly simply by making the appropriate age-field counts on each of the five "affectional warmth" cards. Similar economy (a sixfold reduction in card manipulation) would of course be obtained in every instance in which age was one of the variables on which the tabulation was based.

This principle can readily be extended to two-dimensional preclassification. Thus, if *both* age of mother and sex of oldest child are variables of principal interest, we may use a "grid" approach in which age fields are defined vertically and fields for sex of oldest child horizontally. It is even possible to preclassify for three or more variables, but in some applications this may become cumbersome.

It should be noted that preclassification in no way limits the data-tabulating procedures. Thus, in the example just described the following operations are possible: (i) examination of the relationship of age of mother to one or more additional variables; (ii) examination of the relationship of sex of oldest child to one or more additional variables; (iii) examination of the way in which *both* age of mother and sex of oldest child relate to one or more additional variables; and (iv) examination of the relationship between any other variables studied (the role of mother's age and sex of child being ignored).

The greatest output saving, of course, would result when preclassification variables are related to one or more additional variables. Thus, if six different maternal-age categories and two categories for sex of oldest child serve as the basis for establishing the precoding grid, a 12-fold saving in card manipulation is effected for any analysis in which these two variables are simultaneously related to one or more additional variables.

Careful thought should be given to the selection of variables for preclassification, since it is not convenient to change plans once the input procedures are begun. One cannot readily change, of course, because the basic requirement of this method is that a fixed position for each individual be retained on all storage cards, so that all relevant cards in the set may be used for readout.

"Simultaneous" tables. When one variable is cross-tabulated against another by means of the procedure described above, the minimum total number of manipulations of category cards is equal to the number of cards in the variable that has the smaller number of categories, plus the product of the number of cards in one variable and the number of cards in the other. Thus, in obtaining the information for a 4- by 4-cell table, 20 individual manipulations are required. If many tables are to be run in which one particular variable is cross-tabulated against each of a series of other variables, it is possible to keep the total number of manipulations of the category cards of the first variable to one for each such card. For example, let us assume that we wish to relate the working status of mothers to the following seven dimensions, seriatim: socioeconomic status, age, race, number of children in the family, age of youngest child, husband's occupation, and mother's score on a parental attitude scale. If we had three categories of maternal employment status (full-time employment, part-time employment, and no employment outside the home), and if we completed each table relating maternal occupational status to a second variable before proceeding to another table, each category card for maternal occupational status would have to be manipulated seven times, for a total of 21 card manipulations for this variable. If, however, we take the first-category card for maternal employment status and successively pair it with each of the category cards for all of the other variables being cross-tabulated, we can complete one column in each of the seven tables described with only one manipulation of the first-category card for maternal employment status. This same procedure would, of course, be followed with the other two cards for maternal employment status, with some over-all saving of time.

We have described a simple type of data processing that differs markedly

from many other procedures, machine- or hand-operated. The economy and convenience of the method make it, in our estimation, superior in some cases both to other hand-processing methods and to punched-card operations that rely on central-office machine installations. Speed and flexibility are its major advantages. It has, of course, some limitations: punching by hand is slower than punching by conventional machine methods, and cards can accommodate only a limited number of cases. These drawbacks are in many instances more than outweighed by the advantages. The individual research worker looking for in-almost-any-pocket convenience at in-almost-any-pocketbook price may well wish to consider this method as a means for solving his data-processing problem.

References and Notes

1. Although the illustrative examples in this article are drawn from the behavioral sciences, the general technique is equally applicable to any situation in which an investigator wishes to examine relationships obtaining between two or more variables.
2. Basic descriptions of this procedure may be found in *The Uniterm System of Indexing: Operating Manual* (Documentation Incorporated, Washington, D.C., 1955). The most detailed exposition of the use of punched cards in applying this principle to indexing is a paper by W. A. Wildhack and Joshua Stern, "The peek-a-boo system—optical coincidence subject cards in information searching," in *Punched Cards: Their Application to Science and Industry*, R. S. Casey, J. W. Perry, M. M. Berry, A. Kent, Eds. (Reinhold, New York, ed. 2, 1958).
3. Those who are convinced that there is almost nothing new under the sun will find their opinion supported by evidence which suggests that the basic principle here described is a very old one. On the site of ancient Sumer, clay tablets have been discovered that may have been used in a similar fashion for medical diagnosis. Each tablet referred to a single symptom and listed the diseases in which it was present. A comparison of symptom tablets would presumably have enabled the ancient medic to reach an appropriate diagnosis. [Reported in *Proceedings of the International Study Conference on Classification for Information Retrieval* (Aslib, London; Pergamon, New York, 1957), p. 106.]
4. That there is an upper limit to the number of positions on a card restricts the utility of this method for very large samples, but anyone working with a sample of 400 or less would encounter no difficulties on this score. For studies in which the size of the sample exceeds the number of cases that can be accommodated on a card, the investigator may set up additional sets of cards. For example, if two sets of cards were needed, entries for every table would in effect be obtained by adding corresponding cell entries of two separate tables. There are, of course, limitations to this method of expanding the system's capacity.
5. Although the punching operation in this method of data processing is slower than conventional procedures in which equipment such as an IBM key punch is used, input is probably at least as rapid as that of any method that does *not* require a major piece of hardware for punching purposes.
6. When the categories are not mutually exclusive —that is, when a punch for an individual may be made in more than one category—reliability checks are more problematic (this is also the case with conventional data-storage methods). The total-check-card method is, however, still applicable.

Behavioral Thermoregulation

Behavior is a remarkably sensitive mechanism in the regulation of body temperature.

Bernard Weiss and Victor G. Laties

Behavior is one of the fundamental mechanisms by which organisms regulate body temperature. But, although one can point to numerous illustrations of its importance, quantitative data on the role of behavior in thermoregulation are rare. Among these are Kinder's findings on nest building in rats. Employing a technique originally developed by Richter, she showed that as the ambient temperature fell, rats increased the amount of paper that they used for nest building (*1*, *2*).

In this article we discuss a recent series of studies (*3*) on how behavior contributes to the regulation of body temperature. The major aim of these studies was to specify the relation between body temperature and a response which provided an exteroceptive source of heat.

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The apparatus employed is illustrated in Fig. 1 (*4*). It consists of a Plexiglas cylinder containing a plastic lever attached to a telegraph key. The red-bulb infrared heat lamp above the chamber goes on for a few seconds on certain occasions when the rat presses the lever.

The duration of the burst of heat from the lamp is varied by a timer, and the intensity is varied by a variable transformer. The chambers are located in a refrigerated room, the temperature of which can be controlled to within 1°C. The apparatus that is used to automatically record and program the relevant events is located in an adjoining room.

The fur of the rats used in these experiments was removed by clipping before a session. This procedure makes it impossible for the rat to maintain a normal body temperature at the environmental temperatures used in the experiments.

Initiation

After a rat with no experience in this situation is put into a chamber, it typically spends the first few minutes exploring its surroundings. During this time it occasionally strikes the lever with enough force to close the contacts on the key. This event turns on the heat lamp for several seconds. After this initial flurry of responses the rat usually spends most of the next few hours merely huddling and shivering. Only occasional responses are made during this time. At some point during the session the rat suddenly begins to press the lever at a steady and substantial rate, which it maintains for many hours.

Why does the rat's behavior change so swiftly? It is known that the temperature of a furless rat put into a cold environment undergoes a progressive fall. Perhaps body temperature has to descend to a certain critical point before the burst of heat from the heat lamp becomes reinforcing.

One can test this hypothesis by exposing the rat to cold before putting it into the chamber. Such an experiment was performed with 14 pairs of rats. One member of the pair, randomly selected, was put into a wire-mesh cage in the cold room after being clipped. Its partner was kept at room temperature. Five hours later, both rats were put into test chambers and exposed for 16 hours to a cold-room temperature of 2°C. The heat lamp was set to 250 watts, and each reinforcement (burst of

heat) lasted two seconds. This combination produces a transient temperature rise at the skin surface of about 3°C. Each time the lever was pressed while the lamp was off, the lamp came on. Lever presses made while the lamp was on had no effect.

Rats that had been exposed to normal room temperature before being placed in the test chambers waited a mean of 5.16 hours before starting to work for heat at a steady rate. But rats that had spent the immediately preceding five hours in the cold waited only a mean of 2.04 hours ($t = 2.40$, $df = 13$, $p < .05$). It appears, therefore, that precooled rats start pressing earlier for heat than rats that have not been precooled, presumably because they begin the experiment with a lower body temperature.

Two other studies supported the hypothesis that the critical variable was a drop in body temperature. In one, the relation between thyroid state and thermoregulatory behavior was examined (*5*). It was found that thyroidectomized rats started to work for heat much earlier during a 16-hour session at 2°C than controls that had undergone a sham operation. This was attributed to the fact that hypothyroid animals lose heat more rapidly in the cold than normal animals (*6*).

The other source of support for the hypothesis came from an experiment on cold acclimatization (*7*). Although animals acclimatized to cold show numerous structural and biochemical changes, perhaps the most dramatic difference between acclimatized and normal rats lies in their resistance to cold after their fur has been removed. Rats that have not been acclimatized die at low temperatures; acclimatized rats survive, presumably because their body temperature does not fall to lethal levels (*8*). If the length of the latency (the period before the rats begin to work at a steady rate for heat) is a function of the rate at which body temperature falls in the cold, then acclimatized rats should wait longer than normal rats to begin pressing. They do. There was a considerable difference, with very little overlap, between two groups of eight animals each, one of which had lived about a month at 2°C while the other had been kept at room temperature (25°C).

Despite the evidence favoring the view that a fall in body temperature is the most important factor leading to a steady reinforcement rate, concrete evidence in support of this view was lacking. It was essential to measure body temperature at the same time that the rat was working for heat.

Some preliminary work showed that core temperature changes too slowly, even in an organism as small as the rat, to be sensitive to individual reinforcements. Skin temperature, although quite responsive to individual reinforcements, was rather labile. Subcutaneous temperature also responded to individual reinforcements, but not as transiently as skin temperature. A technique was therefore developed for recording the subcutaneous temperature of a rat moving freely about the experimental chamber. A plastic tube attached to a plastic Luer connector is inserted under the skin on the back and tied to the supraspinous ligament. A purse-string suture is then drawn around a Lucite washer cemented to the tube, and the Luer connector is left projecting from the rat's back. When a rat's temperature is being recorded, a thermocouple (copper-constantan) cemented to a mated Luer connector is inserted in the tube, and the Luer fittings are pressed together. The thermocouple leads to a Minneapolis-Honeywell temperature recorder in another room.

In the next experiment two questions were examined. One was the relation between body temperature and the point at which the rat began to work for heat. The other was the relation between these variables in successive sessions. Each of five rats underwent three

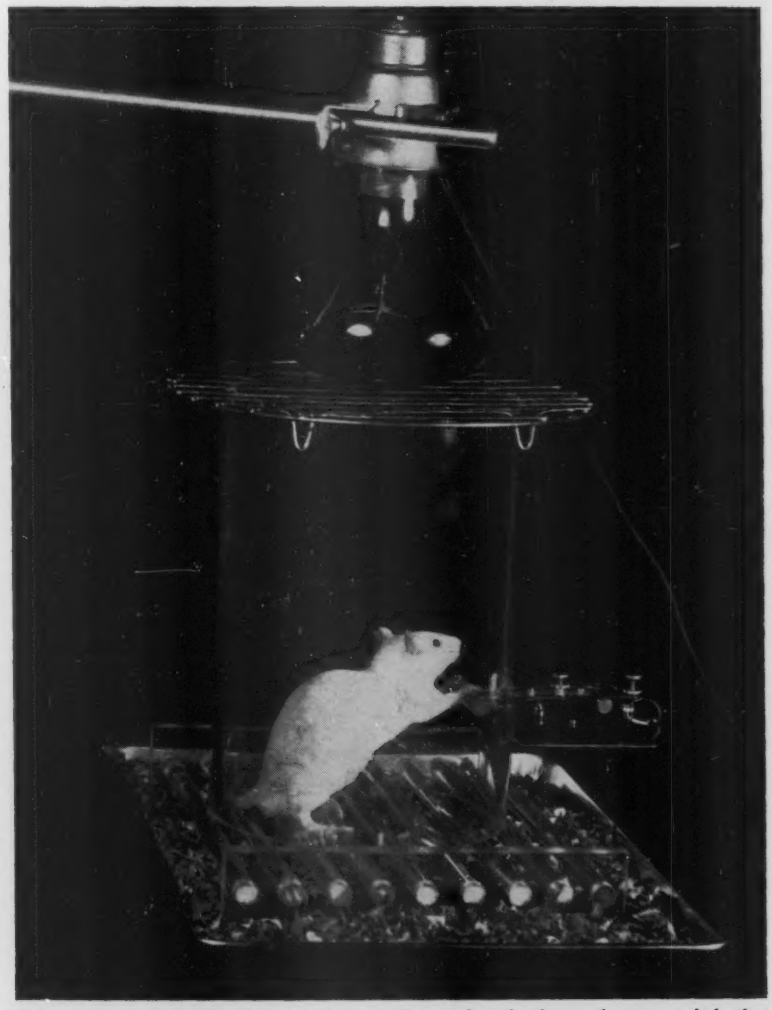


Fig. 1. The heat reinforcement apparatus. Depressing the lever closes a switch that activates the heat lamp.

16-hour sessions spaced a week or two apart. The cold room was set at 2°C, and the heat lamp, at 250 watts. Each reinforcement lasted two seconds, the heat lamp coming on whenever the lever was pressed while the lamp was off.

The mean subcutaneous temperature at the start of the session was about 35°C for all three sessions. Figure 2 shows records from the first session. For each of the rats except rat NN–N, the figure shows the temperature and reinforcement records for the first hour in the chamber and for the hour before and after the start of consistent responding. The upper tracing represents subcutaneous temperature, and the lower represents reinforcements as recorded on a cumulative recorder. Because the latency for rat NN–N is unusually short, all of the first 180 minutes of the session are shown for this rat. Just why rat NN–N started pressing so early is difficult to say. This may be related to the fact that the rat's initial temperature (33.2°C) was the lowest in the group.

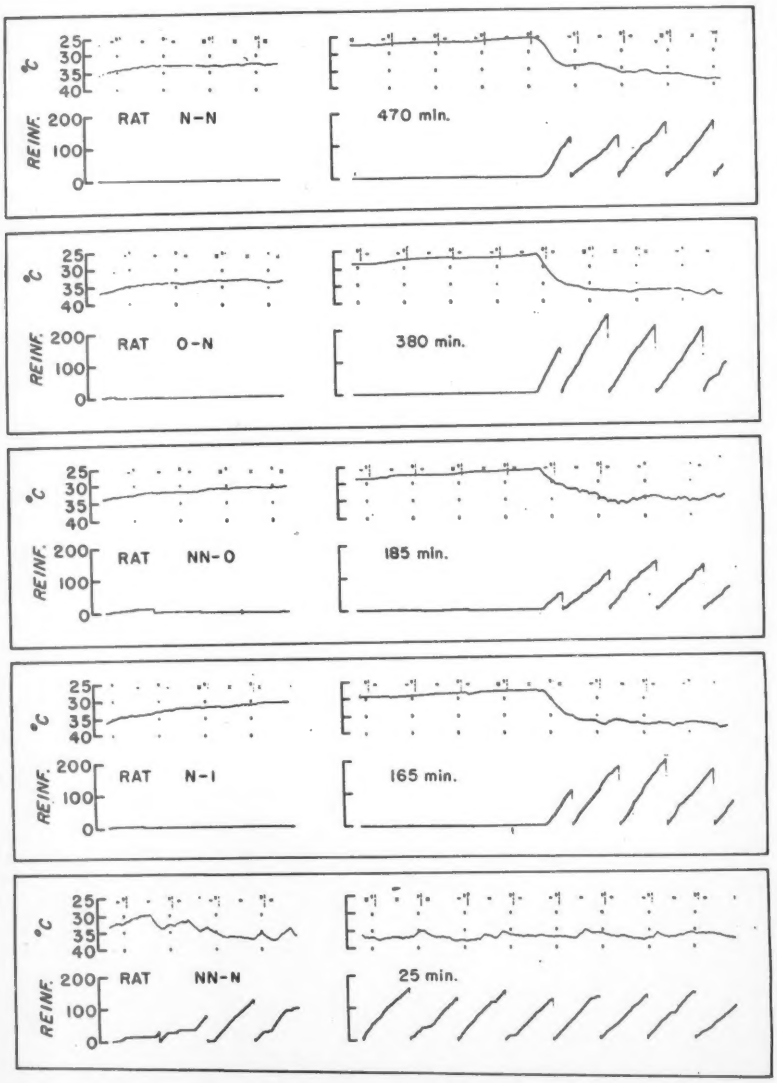


Fig. 2. Parallel records of subcutaneous temperature and reinforcements for all five rats on their first session. Records at left, temperature and reinforcements during the first hour in the cold. Top four records at right, temperature and reinforcements during the hour preceding and the hour following the initiation of steady lever pressing. Record at the bottom (rat NN–N), temperature and reinforcements during the entire first three hours, shown because of the short latency. Also shown for each rat in the records at right is the latency (in minutes) to the initiation of steady lever pressing. Reinforcements were recorded cumulatively, the recording pen resetting to the base line every 15 minutes.

Subcutaneous temperature declines from the time the rat is placed in the chamber until it begins to work steadily for heat. Then, as shown in Fig. 2, subcutaneous temperature rises when the rat begins to respond. The transition from a near-zero reinforcement rate to a steady and substantial one occurs so abruptly that it looks practically instantaneous on the records. Once the rat begins to obtain reinforcements at a steady rate, the temperature climbs rapidly to the level that is maintained for the rest of the 16-hour session.

The data in Fig. 2 are from experimentally naive rats. Does the same sequence of events appear in rats already experienced in the situation? Figure 3 shows, for the same five rats and for three successive sessions, the amount of fall in subcutaneous temperature between the time the rat was placed in the chamber and the time it began to obtain reinforcements at a steady rate. The mean fall in temperature was 8.20°C for the first session, 3.68°C for the second, and 4.64°C for the third. An analysis of variance showed that differences among sessions were significant at the .05 level; the main contribution to this result is the difference between the first session and the two later sessions. It appears, therefore, that once the rat has had experience in this situation, a fall in temperature considerably less than the fall required in the first session initiates responding. What other factors contribute to the change in latency is a still unanswered question.

Maintenance

The peripheral event that seems most closely related to the initiation of a steady rate of working for heat is a drop in peripheral temperature. Another question is, what keeps a rat working for heat? In particular, what governs the rate at which it obtains reinforcements?

Since the rat survives, the reinforcement rate must be governed in part by the body temperature; otherwise, the rat would succumb to the cold or burn its skin. An interesting deduction follows. If the amount of heat per reinforcement increases, the rate should decrease; if the amount of heat per reinforcement decreases, the rate should increase. In a recent series of studies (*9*)

the amount of heat per reinforcement was varied in two ways: by varying the intensity of the heat lamp and by varying the length of time that it remained on. We discuss here only the data obtained by intensity variation, since both methods of varying the amount of heat per reinforcement give the same results.

Six different intensity settings were selected for the experiment: 125, 175, 225, 275, 325, and 375 watts. Figure 4 shows the transient rises in skin and subcutaneous temperature produced in an anesthetized rat by 2-second bursts of heat with different settings of the lamp. The cold room was maintained at 2°C. After a rat was put into the chamber, we waited until it had been responding steadily for at least 30 minutes. Then, according to a randomly determined sequence, it was switched from one intensity setting to another every 30 minutes. A dozen rats took part in this study.

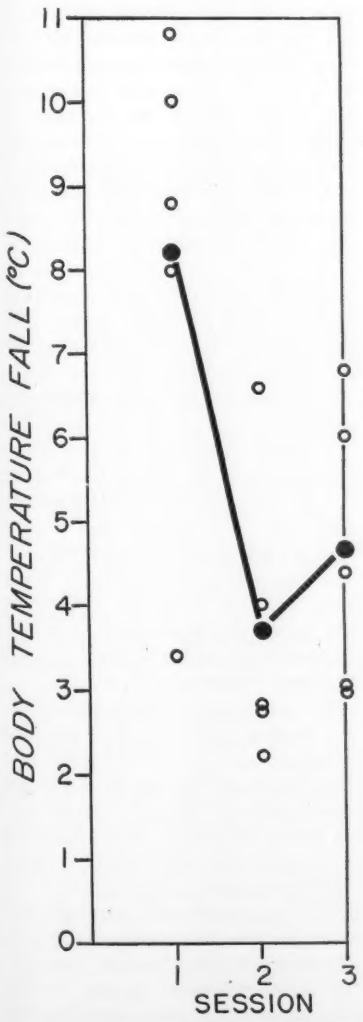


Fig. 3. Amount of fall in subcutaneous temperature before the initiation of a steady rate of working for heat. Data for three successive sessions are shown. Open circles, individual rats; solid circles, the means.

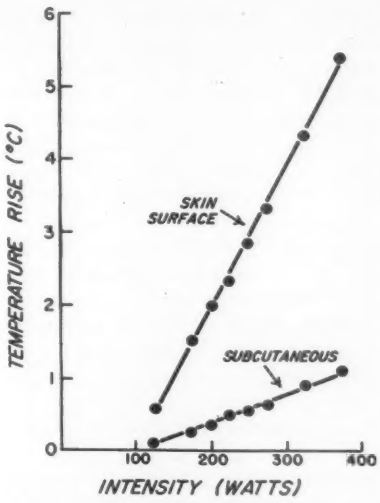


Fig. 4. Transient changes in skin temperature and subcutaneous temperature produced by 2-second bursts of heat with the intensities shown. The subject was an anesthetized rat.

Pooling the data from all 12 of the rats used in the experiment produced a monotonic function between 125 and 375 watts; the greater the intensity, the lower the reinforcement rate. The cumulative records showed that the change in rate following a change in intensity took place at once. But, as Fig. 5 shows, five of the individual curves reverse either at 125 or at 175 watts. Three of the seven rats that did not show a reversal were run at a reinforcement intensity of 75 watts. All three then responded less than they had at higher intensities. One interpretation of this lowered rate of response is that the low intensities are not adequate reinforcers, so that extinction of the lever-pressing response begins to occur. This interpretation is strengthened by the fact that at the lower intensities there were often alternating periods of responding at high rates and of no responding at all. Such behavior is also characteristic of inadequate food reinforcement (*10*).

Once the technique for recording temperature in the freely moving rat had been developed, an obvious application was to perform another experiment on intensity variation. Four intensities were selected: 155, 205, 260, and 310 watts. According to measurements on an anesthetized rat (see Fig. 4), single 2-second bursts of heat at these intensities produced transient rises in

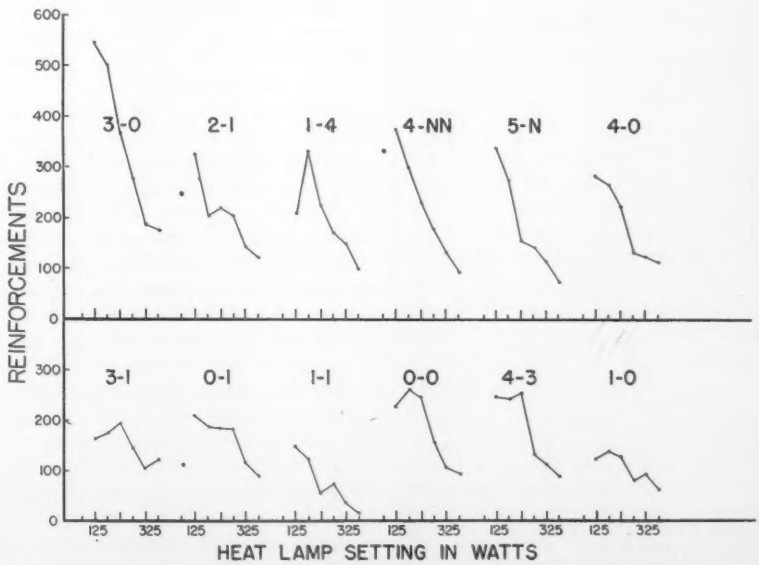


Fig. 5. Number of reinforcements obtained in a 30-minute period at intensity settings of 125, 175, 225, 275, 325, and 375 watts. The data are plotted individually for each rat. The left end of the curve represents 125 watts; the right end, 375 watts. Rats 2–1, 4–NN, 3–1, and 0–1 were also run at an intensity setting of 75 watts. These points are not connected to the remainder of the function.

skin temperature of 1°, 2°, 3°, and 4°C.

The performance of each of eight trained rats was recorded at each intensity for two hours. Figure 6 shows the mean subcutaneous temperature maintained during this two-hour session. The three highest intensity reinforcements led to higher temperatures than the lowest intensity. An analysis of variance indicated that the temperature differences for the four intensities were significant at the .05 level, but only the differences between temperatures at the lowest intensity and temperatures at the other intensities were significant according to t tests.

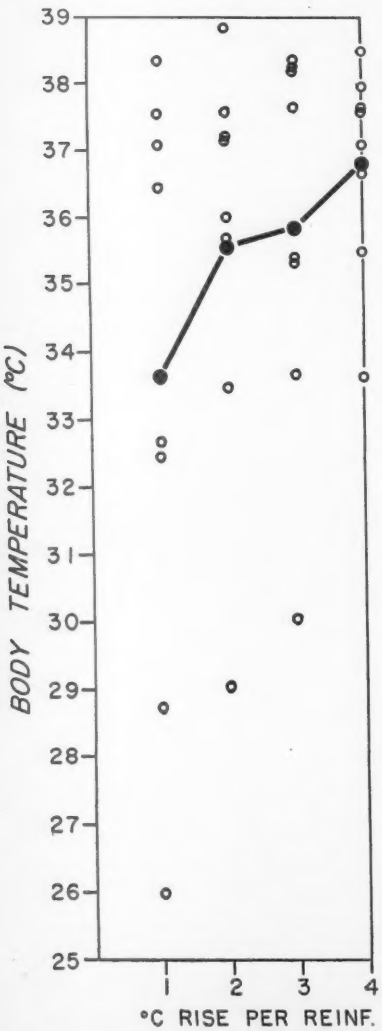


Fig. 6. Mean subcutaneous temperature maintained during a 2-hour period as a function of heat-lamp setting. This setting is given in terms of the rise in skin temperature, in degrees centigrade, produced by an individual reinforcement. Open circles, individual rats; solid circles, the means. These data were obtained by calculating the mean temperature during 24 5-minute segments of the 2-hour experimental period. The temperature represented by the open circles is the grand mean for each rat for the entire 2-hour period.

This finding is similar to that displayed in Fig. 5—namely, a disproportionately low increase in reinforcement rate to compensate for the decline in reinforcement intensity when the latter falls below about 175 watts. The function obtained by connecting the mean values, however, does not reflect the performance of all the subjects. Four rats (half the group) showed no temperature difference as a function of heat-lamp setting. The other four showed a considerable dip at the lowest setting. There was a good deal of consistency in the temperature values for individual rats. The animal with the lowest temperature at the lowest intensity setting also had the lowest temperature at the three higher settings. The four rats that maintained the lowest temperatures at the lowest intensity also maintained the lowest temperatures at the next two highest intensities. At the highest intensity there was more overlap, but the two highest temperatures were maintained by rats from the top half of the group, while the two lowest temperatures were maintained by rats from the bottom half of the group.

The temperature records in Fig. 7 represent the first hour of each 2-hour session at the four different intensity settings of the heat lamp used in this experiment. Rat *A* is the animal designated in Fig. 6 by the second circle from the bottom at a heat-lamp setting of 1°C rise per reinforcement. This rat maintained a relatively low temperature at this reinforcement setting. At the higher reinforcement settings, however, he maintained a peripheral temperature close to the normal value. Rat *B* is designated in Fig. 6 by the topmost circle at a setting of 1°C rise per reinforcement. That is, he maintained the highest subcutaneous temperature of the group at this heat-lamp setting. Note the stability of the temperature tracing, and note how relatively little variation there is as a function of reinforcement intensity. These records illustrate the main finding of this experiment: that rats adjust reinforcement rate in accordance with reinforcement intensity to produce the end result of a constant peripheral temperature.

Metabolic Variables

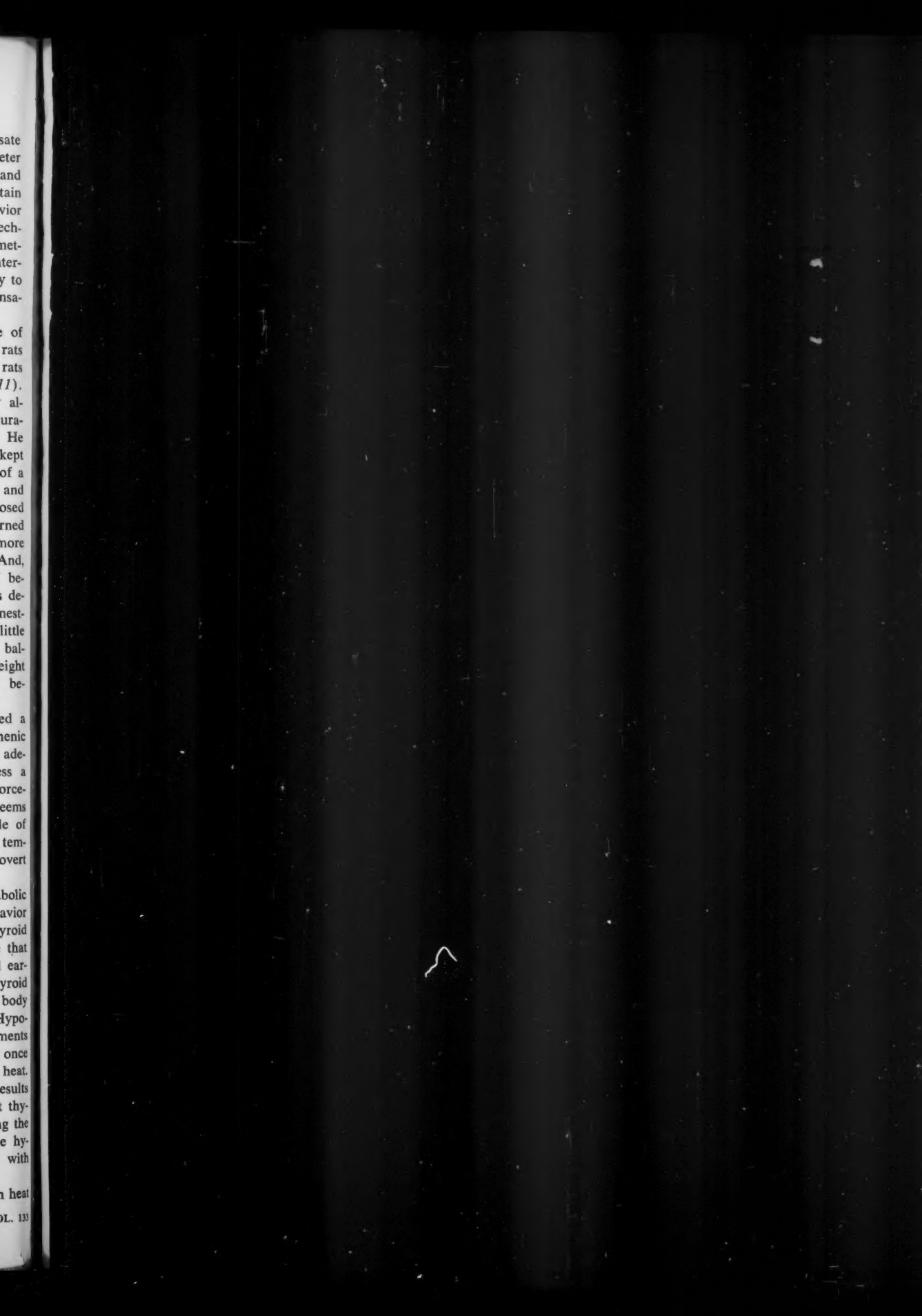
The tendency of rats to compensate for variations in the intensity parameter by variations in reinforcement rate and the stability with which they maintain peripheral temperature by such behavior suggest that the heat-reinforcement technique might be useful for studying metabolic variables. That is, if we interfere with or enhance the rat's ability to produce heat, would we find compensatory changes in behavior?

In some earlier experiments one of us found that starved and underfed rats responded more often than control rats to obtain heat reinforcement (*11*). Hamilton varied the technique by allowing the rats to determine the duration of the reinforcement (*12*). He found that food-deprived animals kept the lamp on for a greater portion of a session than controls did. Carlton and Marks (*13*) found that cold-exposed rats that had suffered weight loss turned on a hot-air blower in the cold more frequently than control rats did. And, studying a quite different kind of behavior, Kinder (*2*) found that rats deprived of food increased their nest-building activity. There seems little doubt that the disturbance of heat balance produced by starvation and weight loss is reflected in compensatory behavior.

A higher proportion of rats fed a diet deficient in the vitamin pantothenic acid die in the cold than rats fed an adequate diet. The former also press a lever at a higher rate for heat reinforcement than the latter (*11*). It seems likely that this is another example of how the inability to maintain body temperature in the cold is reflected in overt behavioral thermoregulation.

Our most complete data on metabolic state and thermoregulatory behavior come from a series of studies on thyroid function (*5*). It was stated above that hypothyroid rats begin to respond earlier during a session than euthyroid rats, presumably because their body temperature falls more rapidly. Hypothyroid rats also seek reinforcements at a higher rate than euthyroid rats once they begin to work steadily for heat. Part of the difference, at least, results from the fact that rats with intact thyroids pause more frequently during the session than hypothyroid rats; the hypothyroid rats work at the task with greater constancy.

One can counteract the deficit in heat



production that accompanies hypothyroidism by administering a thyroid hormone. In one experiment we were able to produce a fall in the frequency of heat reinforcements sought by thyroidectomized rats by administering the thyroid hormone 3,5,3′-1-triiodothyronine via their drinking water. The fall was great enough, in fact, to carry the rate below that of their intact controls.

With the present system, then, metabolic variables that influence the heat-production capacity of the rat are reflected in the rate at which it works for heat.

Basis of Thermoregulatory Behavior

The experiments under discussion were directed toward the question of how behavior contributes to the regulation of body temperature. Two aspects of this question were considered: the factors that lead to the initiation of thermoregulatory behavior and the factors that maintain it.

By correlating subcutaneous temperature with the behavior of pressing a lever for brief bursts of heat, we were able to show that the rat's behavior in the situation we have described results in a fairly constant peripheral temperature. The very precision with which the rat regulates this temperature poses a problem. Why does a large drop in body temperature seem necessary to initiate responding, while much smaller fluctuations govern reinforcement rate once a substantial rate of responding is established?

One reasonable possibility is that when the rat is first placed in the cold, lever pressing must compete with other responses elicited by the cold, such as shivering and huddling. When shivering and huddling can no longer avert a further decline in temperature, they may then be replaced by gross motor activity. When such activity accidentally results in depression of the lever, the burst of heat from the heat lamp produces such a profound change that it is quickly followed by other presses. A sudden onset of responding also appears when food, rather than heat, is the reinforcement (*14*).

A more general question may also be asked. What do these data demonstrate about the way in which behavior fits into the pattern of regulatory processes that sustain life?

In most of the experiments set up to answer such questions, factors that control eating and drinking have been studied—to determine, for example, whether an animal can compensate for a diet deficient in a particular substance by the appropriate selection of nutrients. Such studies have demonstrated that under many conditions animals do vary ingestive behavior to compensate for deficiency states. But in numerous instances they do not. Perhaps the reason for the substantial proportion of failures in experiments on eating and drinking is the long chain of processes that intervene between behavior and the ultimate effect. By contrast, the effect of heat is practically instantaneous. This is probably the reason why behavior seems so exquisitely attuned to the regulation of body temperature.

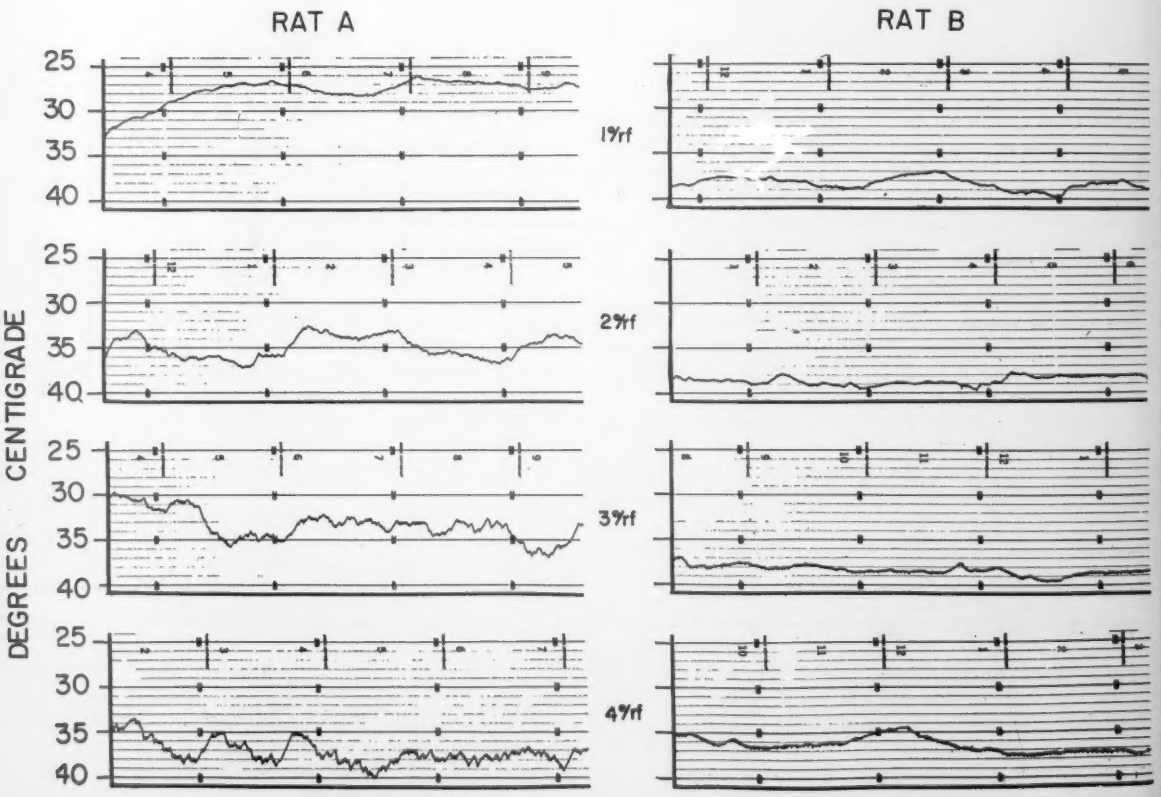
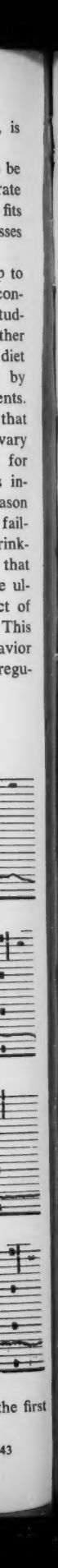


Fig. 7. Records of subcutaneous temperature for two rats at the four different heat-lamp settings noted. Only the record for the first hour of each 2-hour session is shown. These rats belong to the group of Fig. 6 (see text).



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Science in the News

The Test Ban: The Russians Now Say That the Inspection System Is Only "Symbolic"

The negotiations at Geneva have reached a critical point, and the outlook is dim. It is still barely conceivable that the recent Soviet attitude is merely a bluff. But this hope, rather widespread when the first signs of a hardening of the Russian line appeared, has steadily lost ground.

We offered a number of concessions: a reduction of the number of detection sites on Russian soil, a longer extension of the unpoliced moratorium on small tests, a willingness to let the Russians inspect the devices we would use for the testing program, and several others. For a time the argument was made that the apparent lack of Soviet interest in these concessions was merely a little tactical bluffing, and that they would, in due time, come up with counterproposals of their own. But hopes of this sort have all but disappeared in the light of the continued lack of interest of Tsarapkin, the chief Soviet negotiator, and by the recent attitude of Khrushchev as reflected in his interviews with Llewellyn Thompson, our ambassador to Moscow, and with Walter Lippmann.

The Soviet attitude shows most clearly in the demand that the previously agreed to administrative control by a neutral be replaced by a tripartite administration, representing East, West, and neutral views, with unanimous agreement required for any affirmative action. In effect, this means that the Russians would have the right to veto any particular proposed inspection.

Nondetecting Detection

Under such circumstances the value of the inspection system as a deterrent to clandestine testing becomes almost nonexistent, and the Russian delegate, according to reports leaking out of the meetings, has frankly taken the position that the detection system, and the inspections, will not really be intended to deter cheating, but will be only "symbolic" moves reflecting the good intentions of the treaty signers. If this view is accepted, it follows that the detection system should be as unelaborate as possible, since there is obviously no point in wasting a lot of money setting up a detection system which is not intended to detect anything.

There is no chance of a treaty's being signed so long as the Russians insist on the right to veto any inspection. Whatever might be said about the wisdom of continuing the present *de facto* ban on testing, nothing can be said for formalizing this ban, which in effect would abandon the position agreed to until now by everyone, including the Russians, that disarmament agreements should be accompanied by a reasonable inspection system to deter cheating. This is what provoked the President's remark at his press conference that "it is quite obvious that the Senate would not accept such a treaty, nor would I send it to the Senate, because the inspection system [based on the right of each nation to veto any inspection that might prove embarrassing] would not provide any guarantees at all."

The common view is that the Russians have now decided that the advantages of a test ban are not alone sufficient to overcome their distaste for inspection, and that they now feel the treaty is worth considering only as part of a larger scheme of disarmament proposals.

This leaves the Administration with the problem of what to do about the *de facto* ban. The public attitude of the Administration, again as expressed at Kennedy's press conference, is that "if there is any chance at all of getting an agreement on a cessation of nuclear tests, regardless of what appear to be the obstacles, I think we should press on . . . I still believe that Mr. Dean [the chief American negotiator] should continue to work at Geneva."

Administration's Dilemma

It may be that the Administration would consider giving in to the Soviet view, and allow the Geneva talks to drag on another 6 months, and then be merged with the general disarmament talks which are expected to be underway then. But there are strong pressures against this course. Last week, after unfolding the Anglo-American position gradually since the talks resumed on 21 March, the Western negotiators placed before the Russians the full text of a draft treaty we were prepared to sign. We have now laid all our cards on the table, and there is nothing more of an affirmative nature that we can do. The Russians have showed no interest at all in the Western concessions. ("Much ado about nothing," Tsarapkin has told the press.) Their principal response, the demand for a veto, rather than being a counteroffer, is a retreat from a position they had earlier accepted.

The original "gentlemen's agree-

ment" in 1958 to stop all tests has now dragged far beyond its original 1-year duration, and the position of both the old and new Administrations has all along been that the unpoliced moratorium will be permitted to run only as long as there seems to be a realistic chance of reaching a formal treaty. The Administration must now decide, in the face of what has happened in Geneva, whether to tacitly admit that its warnings about resuming testing if the Russians did not show they were serious about the negotiations was nothing more than empty talk.

This raises the problem of how, if a decision to resume underground testing is made, it is to be presented to the rest of the world, or alternatively, if the *de facto* moratorium on testing is to be continued, how this is to be explained to the critics, inside and outside Congress. These critics have been persuaded to accept relatively quietly the continued extension of the unpoliced ban this long only on the assurance that testing would be resumed once it had become clear that the Russians were not interested in serious negotiations.

Unpleasant Decision

Whatever the decision, and it is likely to be made quite soon, it will be a difficult one for the Administration, and will subject the Administration to a great deal of criticism.

We have never, in so many words, explicitly said we would resume weapon testing if the negotiations were to fail. There have been rather explicit statements about undertaking nonmilitary experiments, either for improving detection systems or for exploring the peaceful uses of nuclear explosions, such as the proposal to use such an explosion to create an artificial harbor in Alaska.

But it is unclear whether a resumption of testing for nonmilitary purposes would do much to soften the certain displeasure of the neutralist nations. It will not be difficult, and probably not even inaccurate, for the Russians to tell the rest of the world that any resumption of testing would, in fact, be a resumption of some phase of weapon testing, regardless of whatever incidental purposes it might serve.

The result of whatever decision is made is bound to be unhappy. But the alternative of simply letting things drag on aimlessly at Geneva, although perhaps easier, seems at least as dismal. —H.M.

News Notes

The Krebiozen Trial

The Krebiozen trial in Chicago has been called off until the fall. The case has substantial implications for the scientific community at large, since it involves the question of how severely a scientist can criticize the work of a fellow scientist without opening himself to a libel suit.

Krebiozen is a drug purported to be effective against cancer, which, so far, has won little scientific support outside the small circle of its sponsors. One of the sponsors, Andrew C. Ivy, head of the department of clinical sciences at the University of Illinois, filed a suit for $300,000 against George C. Stoddard, chancellor of New York University. Ivy charged that Stoddard had attempted to destroy his reputation as a scientist. The two men were at one time vice president and president, respectively, of the University of Illinois.

The judge in the case ruled that the trial should be put off until the government's National Cancer Institute could evaluate the claims made for the drug, although attorneys for both sides had agreed that the effectiveness of the drug was not the issue in the trial—that the issue was, rather, whether Stoddard had gone beyond the bounds of legitimate criticism in his implication that Ivy was not merely wrong but wrong to the point of professional incompetence.

The controversy is more than a decade old, and both men have suffered through their involvement. Professional sentiment in the field is overwhelmingly against Krebiozen, and in response the Krebiozen supporters have been rather free in suggesting that there is a conspiracy afoot to keep Krebiozen from being recognized and to destroy the reputations of its sponsors.

The Secretary of Health, Education, and Welfare, Abraham Ribicoff, responded to the judge's request for an official evaluation by reiterating the Cancer Institute's readiness to evaluate the drug whenever the Krebiozen supporters were prepared to cooperate in the standard procedures.

According to a statement last year of the Citizens Emergency Committee for Krebiozen, "In view of the history of so-called 'evaluations' in the past, Dr. Ivy does not wish to provide the opportunity for any new 'committee' to use such an evaluation as a device to prevent an actual clinical test because of the risk of the negative influence of such a committee. Such a negative 'committee evaluation,' instead of actual clinical tests, could set Krebiozen back another 10 years."

The National Cancer Institute uses such a committee evaluation as standard procedure to decide whether it is worth going ahead with full clinical tests, which would cost several hundred thousand dollars.

Shake-up in Soviet Science

The controlling influence over scientific development in the Soviet Union appears to have been taken out of the hands of the Academy of Sciences. A new agency, headed by a nonscientist and former production executive, has been given over-all responsibility for the control of all scientific research, and of Soviet contact with foreign scientists.

The new agency is called the State Committee for Coordination of Scientific Research Work. It is headed by Lt. Gen. Mikhail V. Khrumichev, former head of Soviet airplane production and, more recently, deputy chairman of the State Planning Committee. His new job carries the rank of deputy prime minister. The agency is apparently designed to direct Soviet scientific work toward fields holding the strongest promise of practical applications. One of its principal announced objectives is to shorten the time between the making of a scientific advance and its adaptation to practical uses.

The change marks a clear decline in the influence of the Soviet Academy, which had been criticized for allowing needless duplication and for "irrational" allocation of human and material resources available for research.

The reorganization, according to one view, is simply a logical manifestation of the tendency to decentralize that was apparent in the Khrushchev shake-up of industry in 1957 and of agriculture in 1959. The country's 200 specialized research institutes have been taken out from under the central direction of the Academy, which, in this view, will now be free to concentrate its efforts on pure research, leaving the problem of administering and coordinating industrial research to professional industrial administrators.

Other observers have stressed the emphasis, in the announcement, on avoiding duplication and channeling work into the most economically prom-

ising areas; this suggests to them less a decentralization than a shift toward greater emphasis on practical applications than on pure research.

Religion and the Election

The University of Michigan's Survey Research Center, one of the more authoritative voices in a field where almost no one hesitates to dismiss opinions that do not coincide with his own, has completed a study that suggests Kennedy lost a net 1.5 million votes because of his religion.

This is not the end of the discussion of who gained from the religious issue, and how much. The size of the sample, 1500, involves a margin of uncertainty as large as the net voting shift reported, assuming the sample was perfectly drawn and perfectly analyzed. Here are the center's estimates:

"Outside the South, Kennedy gained over 5 percent of the two-party vote from fellow Catholics, but lost over 3½ percent from Protestant Democrats and independents, leaving him with a net gain of over 1½ percent.

"Inside the South, Kennedy's gain from Catholics was less than 1 percent, his loss from Protestant Democrats and independents exceeded 17 percent, for a net loss of more than 16 percent.

"Nationally, his gains from Catholics amounted to more than 4 percent, his losses from Protestant Democrats and independents were about 6½ percent, and his net loss over 2 percent of the 68 million votes cast."

Biomedical engineering. Engineering and medicine will be combined in a graduate curriculum leading to a Ph.D. in "biomedical engineering" at three eastern universities—Johns Hopkins, Pennsylvania, and Rochester. The universities will offer the program in September. According to a Johns Hopkins announcement, the new program will "train students in advanced engineering subjects of particular pertinence to research in biological systems, and offer systematic study in how the principles of physical and engineering science apply to biological systems."

Alan Gregg biography. Any material that has to do with the life of Alan Gregg, late of the Rockefeller Foundation, will be welcomed by his biographer, Dr. Wilder Penfield, Montreal Neurological Institute, Montreal, Canada.

Research Notes

Ampoules containing 200 mg of mixtures of pure **fatty acid methyl esters** will soon be available for distribution to qualified investigators in whose research programs such materials are needed. Investigators desiring these samples should describe briefly the research purposes for which they are to be used. The committee advising on this distribution program will attempt to fill all deserving requests. Letters should be addressed in duplicate to Dr. William H. Goldwater, Metabolism Study Section, Division of Research Grants, National Institutes of Health, Bethesda 14, Md.

* * *

A bibliography listing 380 U.S. Government research reports, foreign translations, and other technical documents on **Communist Chinese science and technology** has been published by the Office of Technical Services, Business and Defense Services Administration, U.S. Department of Commerce, Washington 25, D.C. The bibliography (SB422) is available from OTS for 10 cents.

* * *

The maximum dollar amount for research grants under the **mental health** small research grant program of the National Institute of Mental Health has been established at $3500 plus indirect costs. Support is provided for 1 year only, and is not renewable.

The program is intended to encourage the initiation of research in the behavioral, biological, and medical sciences relevant to mental health, by providing limited funds in a relatively rapid and flexible manner. It is designed to be of particular value to promising young investigators or to investigators who are working in institutions whose resources are not readily available for the support of preliminary research explorations.

* * *

Eight **standard hydrocarbon blends** are now available from the National Bureau of Standards for calibrating instruments used in analyzing gasoline and blending stocks. These standard samples—primarily intended for mass spectrometer calibration—are mixtures containing seven or eight pure hydrocarbons representing C_7 and C_8 paraffins and cycloparaffins in typical virgin and catalytically cracked naphthas. The standards may also be applicable for infrared and gas chromatographic techniques.

Scientists in the News

George B. Kistiakowsky, chairman of the President's Science Advisory Committee under Eisenhower, has received the George Ledlie prize, Harvard's highest faculty award. The prize is awarded every 2 years to the faculty member who has made "the most valuable contribution to science, or in any way for the benefit of mankind." Kistiakowsky was cited for his work both as a science adviser to the government and as a physical chemist.

Owen W. Wangensteen will receive the $5000 award of the Passano Foundation for work in surgical techniques and postoperative therapy and for his work as a teacher. Five of the 19 previous winners or co-winners of the annual medical award have subsequently received Nobel prizes. Wangensteen is on the faculty of the University of Minnesota School of Medicine.

John H. Lawrence, professor of medical physics and director of the Donner Laboratory at the University of California, Berkeley, will spend part of the spring semester in India giving a series of lectures on atomic energy in medicine and working with H. J. Bhabha, chairman of the Indian Atomic Energy Commission.

Maj. Gen. **Clement F. St. John**, commander of Walter Reed Army Medical Center in Washington, D.C., has been appointed director of the Medical Center of the University of Cincinnati.

John F. G. Hicks has been named associate director of the Battelle Institute. A chemist, he is at present vice-president and technical director of Corning Glass.

Wilhelm S. Albrink has been appointed professor and chairman of pathology at the medical center of West Virginia University. His wife, **Margaret Albrink**, has been appointed associate professor of medicine. Both are currently members of the medical faculty at Yale.

John G. Trump, professor of electrical engineering at MIT, will receive the 1961 Lamme gold medal for work in the design of particle accelerators and x-ray generators which can be used in cancer therapy. The award is made by the American Institute of Electrical Engineers.

Wright Rowe Adams, chairman of the department of medicine at the University of Chicago, has been appointed to the new post of associate dean of the biological sciences. **Leon Jacobson**, director of the Argonne Cancer Research Hospital, which is operated by the University of Chicago for the Atomic Energy Commission, has been appointed temporary chairman of the department of medicine.

Ernst Knöbil, now assistant professor at Harvard Medical School, has been appointed to the new Mellon professorship of physiology at the University of Pittsburgh. The chair was endowed by a grant from the Richard King Mellon Foundation.

Howard T. Karsner, a civilian employee of the Navy, has received the Navy's annual Conrad award for his work in submarine and aviation medicine. The award is named for Captain Robert Conrad, who, as head of the planning division of the Office of Naval Research, organized the Navy's basic research program.

Charles Huggins, director of the Ben May Laboratory for Cancer Research at the University of Chicago, has received the highest honor of the Peruvian Government, the "Order of the Sun." While visiting in Lima, he was called to the presidential palace, with no advance notice that he was to receive the gold medal.

Ernest C. Pollard, chairman of biophysics at Yale, has been appointed professor of biophysics at Penn State. This makes permanent a change made last July, when Pollard came to Penn State as a visiting professor.

Otto H. L. Heckmann, director of the observatory at the University of Hamburg, will receive the James Craig Watson medal for astronomy from the U.S. National Academy of Sciences. He heads an international project to catalog the motions of 180,000 stars visible in the Northern Hemisphere. Heckmann is known for his work in cosmological theory.

Columbia University has announced the appointment of **Robert W. Houston**, professor of chemical engineering, as laboratory director of the Industrial Reactor Laboratories at Plainsboro, N.J. Columbia has signed an agreement to operate the facility, which is owned by ten industrial corporations engaged, to varying degrees, in nuclear research. The university has a 9-percent share in use of the laboratories, which include one of the world's largest privately owned nuclear research reactors.

Kenneth M. Endicott, director of the National Cancer Institute, Bethesda, Md., has announced the appointment of **Carl G. Baker** as associate director for program and of **C. Gordon Zubrod** as director of intramural research. Baker was formerly assistant director, with responsibility for intramural nonclinical research. In his new position he will work closely with Endicott in coordinating the major institute programs and with the institute's top extramural advisory committees on policy matters.

Zubrod, formerly clinical director of the institute, has been active in research on the use of drugs in cancer patients. In his new position he will direct both clinical and nonclinical research.

Robert W. Noyes has been appointed professor and head of the department of obstetrics and gynecology at Vanderbilt University School of Medicine, effective 1 October. Noyes is at present associate professor at Stanford University.

Albert V. Baez, a former associate professor of physics at Harvey Mudd College, has been appointed chief of UNESCO's Division of Teaching Basic Sciences in Higher Education. Baez is expected to assume his duties at UNESCO headquarters in Paris sometime this year.

Maurice Ewing, professor of geology at Columbia University and director of the Lamont Geological Observatory, has received Dickinson College's $1000 Priestley memorial award for his research in oceanography and earth sciences.

Lloyd A. Wood, former chief of the Office of Research Grants and Contracts of the National Aeronautics and Space Administration, has been appointed director of the Physical Sciences Division of the Air Force Office of Scientific Research, Air Force Research Division, Washington, D.C. In his new post he will manage the largest directorate of the AFOSR and will direct the spending of some $15 million a year for basic research in the fields of nuclear physics, general and solid-state physics, and geophysics.

Edward U. Condon, head of the physics department of Washington University, St. Louis, has been named chairman of the Editorial Board of Directors of *International Science and Technology*, a new magazine which will be launched in January 1962, by Conover-Mast Publications Inc., to serve scientists and engineers in industry. **Robert B. Colborn**, who has been with McGraw-Hill Publishing Co. since 1936 and has been assistant managing editor of *Business Week* for the last 10 years, will be editor of the new publication.

Recent Deaths

Elda E. Anderson, Oak Ridge, Tenn.; 61; health physicist at Oak Ridge National Laboratory; former president of the Health Physics Society and chairman of the American Board of Health Physics; 18 Apr.

S. Howard Armstrong, Chicago, Ill.; 49; professor of medicine at the University of Illinois and dean of Cook County Graduate School of Medicine; 11 Mar.

Jules Bordet, Brussels; 90; winner of the Nobel prize for medicine and physiology in 1919; his discoveries in the field of serology were widely applied for the diagnosis of typhoid, tuberculosis, and other infectious diseases; the Wasserman test for diagnosis of syphilis is based on these principles; 6 Apr.

Paul Frederick Brande, Cambridge, Mass.; 30; fellow in physiology at the Harvard Medical School; 1 Apr.

J. Ben Hill, University Park, Pa.; 81; professor emeritus of botany at Pennsylvania State University; 31 Mar.

Matthew A. Hunter, Troy, N.Y.; 82; metallurgist; dean emeritus of Rensselaer Polytechnic Institute; 24 Mar.

Sir **David Rivett**, Sydney, Australia; 75; chemist; played a major role in the movement to reclaim millions of acres of barren land in the Australian "outback"; had served as chairman of the British Commonwealth Council of Scientific and Industrial Research and as president of the Australian and New Zealand Association for the Advancement of Science; 3 Apr.

Raymond J. Strawinski, Baton Rouge, La.; 44; specialist in hydrocarbon microbiology; associate professor of bacteriology, Louisiana State University; 27 Jan.

Erratum: The officers of the American Meteorological Society said to have been elected this year in a recent news note [*Science* **133**, 322 (1961)] were elected last year to 2-year terms.

Book Reviews

The Education of Nations: A Comparison in Historical Perspective. Robert Ulich. Harvard University Press, Cambridge, Mass., 1961. xiii + 325 pp. $6.75.

Robert Ulich's book on the educational systems of five modern nations, including Russia and the United States, is particularly well designed to bring understanding, for he begins with a review of the nearly common heritage of 700 years, from the high Middle Ages to the age of industrial democracy. At every point, moreover, the author suggests parallels or makes analogies that show without didacticism how tightly linked the educational practice and the cultural assumptions of a period or country are. He is as ready to speak of our judgments of modern art in connection with the technological revolution as to speak of Pascal and Kierkegaard in a paragraph about the integration of science into the world of moral ideas.

If one adds to these evidences of a mind able to move easily and aptly within the realm of intellect the fact that *The Education of Nations* is written in ordinary English, which is to say, nowadays, extraordinary English, free from jargon, preciosity, or affectation of any kind, one is led to conclude that here is an uncommon work of manifest utility. The many persons from every walk of life who are at the moment gravely concerned about American schools would do well to provide themselves with a little detachment and perspective by assimilating the contents of Ulich's survey. They would find it assimilable, I am sure, not only by virtue of its lucid prose, but also by virtue of its unhurrying pace and quiet tone. Though serious from beginning to end, the work is a kind of *causerie* by a man who has read much, a man who remembers what he once read rather than copies out what he has just read. He never presses too hard on the point he makes or the conviction he is moved by.

And this perhaps is the only weakness of the work, at least for readers who have a good grasp of the intellectual history of modern Europe and who have some acquaintance with the recent debates about education in England and on the Continent. Such readers are charmed by the author, and instructed in certain details (particularly about Russian education), and occasionally led to doubt or disagree; but they are not stirred into sharing a vision of past, present, and future. I do not mean that Ulich lacks an individual voice. He is a finely tempered rationalist, who balances reason with moral and esthetic sensitivity. He is a cosmopolitan mind of that rare sort to whom internationalism is a positive premise, not a means of expressing ill-digested resentments. No one would want to upset this urbane equilibrium by a greater dose of partisanship. But what one would wish from so competent a guide, from a spirit so self-aware and judicious, is—if I may press the image of judgment—a stronger charge to the jury.

JACQUES BARZUN
Columbia University

Sea Birds. Charles Vaucher. Translated from the French by James Hogarth. Oliver and Boyd, London, 1960. 254 pp. Illus. (225 photographs, 15 in color). £5 5s.

This English edition of *Oiseaux de Mer* (Delachaux and Niestlé, Paris, 1958) is primarily a remarkable collection of well-reproduced photographs, almost all of them of birds which breed exclusively on oceanic islands or coasts; but the text is well written, and the introductory chapter, "Islands of the birds," and the 14 chapters devoted, respectively, to the fulmar, the cormorant, the shag, the gannet, the common eider, the shelduck, the arctic skua, gulls (four species), the kittiwake, terns (seven species), the razorbill, the guillemot, the puffin, and the oystercatcher, ringed plover, and turnstone are not to be dismissed as mere accompaniment or *obbligato*. I have listed these names to make clear which sea birds are dealt with. As the author states in his foreword, the book is concerned only with certain species, notably those which live on the Farne Islands off the coast of Northumberland, Bass Rock and Tentsmuir Point in Scotland, the islands of the Stockholm Archipelago, and the islands near the biological station of Tvärminne in Finland. The peregrine falcon, which often preys upon the sea birds of northern Europe, is not discussed.

Coverage of the above-named 25 species is not equal by any means, the decidedly photogenic adult gannet being represented by no fewer than 26 photographs, including three striking color studies, one of which is used as a frontispiece and also on the dust jacket. Admirers of Vaucher's photographs of flying gannets will be hauled down from ecstasy by the humble little portrait of a 3-day-old gannet, which reminds one of a singed, decapitated hedgehog. I studied this photograph a long time before I found the creature's head. Finally, convinced that the eye was nowhere visible, I realized that what I had been calling the back of the neck was the top of the head and that the slightly opened bill was pointed almost straight down. Another nonphotogenic subject, the rock pipit (page 245), is the only passeriform bird pictured.

Three photographs are of seals on the Farne Islands, and several photographs are of the shore with its waves, limpets, barnacles, seaweed, "polished rocks," and spider crabs. When I first looked at the lower of the two pictures captioned "Molluscs and seaweed carpet the rocks" on page 24, I misidentified some of the "molluscs" as cliff swallow nests. I continue to be disappointed that the handsome little alcid known as the black guillemot, the bird the Eskimos call the *pitseolak*, is represented by only one photograph, and this a not particularly distinguished one. But what *Sea Birds* lacks in black guillemots is compensated for by seascapes as thrilling as the oil paintings of Frederick Waugh, by a remarkable twosome showing the wing-tip patterns of the herring gull and common gull (page 138), and by many action studies of birds in flight.

I am a very poor photographer, but I have devoted much time to bird painting; Charles Vaucher's photographs reveal certain facts about what a human being can hope to see of birds, and these facts may well be discussed here. Please look at the well-composed picture of flying gannets on page 84; here it will be observed that in the uppermost bird the white under side of the body, the part below the nearer wing, is *lost completely* to the eye as a result of shadow plus reflected color. The average bird painter (the word *average* is not intended to be snide) would feel it necessary to show the whole bird in order to give the viewer his money's worth, so to speak; but Nature seems to delight in breaking up shapes, in dissolving edges, and in neutralizing, changing, even destroying "local color." The top surface of a flying crow can flash pure white as the glossy plumage catches the sun; a flock of flying or running wild turkeys can lose their darkness and their gorgeous iridescence entirely in certain lights; the gray of an ordinary catbird (*Dumetella carolinensis*) can become as blue as the blue of an adult male blue grosbeak (*Guiraca caerulea*) on a cloudless summer day. This I know from memorable experience: I once shot a blue grosbeak in a stand of locust saplings; I was dead certain that my bird was of that species; but the dead bird that I picked up was a catbird.

The Swedish artist Bruno Liljefors knew wonderfully well how parts of birds and mammals can disappear as the sun-struck, shadow-marked creatures stand or crouch or move about in their habitat. One of his large oil paintings of a company of curlews is a meaningless mass of daubs at close range, but at a distance the eye finally sees the curlews in the grass, and the mind grasps the all-important fact that the process of finding the bird-shapes on the canvas has been very like that of finding the birds themselves in their actual habitat. It can be argued that more is to be expected of the artist than of the camera; but to my way of thinking the really great artist must fully understand *all* relationships between the viewer and that which is viewed; let him eventually become an abstractionist; let him eventually swing completely away from representation of that which is usually called and thought of as visible; even so, he will—even as did Picasso, who had his academic period—become the greater for having gone through the schooling process, for having first learned, then deliberately, wittingly, intentionally unlearned.

What I am trying to say is that the photographs in such a work as *Sea Birds* can be a guiding force for a bird artist. No honest artist will allow himself to copy a photograph directly; but he will study shapes, edges, highlights, and shadows avidly, hoping to come to a full understanding of them. Especially will he study eyelids and mouth corners and feet—parts of birds which dry up and lose shape badly after preparation as museum specimens.

The ecologist, as well as the artist, will find *Sea Birds* stimulating. Vaucher does not, I rejoice to observe, feel it necessary to employ the complex, hyphenated terms so many ecologists employ. He is, none the less, a sound student of habitats; his presentation as a whole is proof of this. Nowhere in *Sea Birds* is there an element that does not belong in a very real sense to the *oikos* about which the author so clearly speaks through both photographs and text. Here are the cliffs with their masses of guillemots and gannets, the position of each bird so determined by "space requirements" as to give the colony a surprising symmetry and orderliness. Here is the pounding surf, with the rocks it has worn smooth, the chasms and arches it has formed, and the birds that have found nesting places thereon. Here are the flowers known as thrift and sea-campion and the terns that find summer shelter among them. In the so-called "descriptive summaries," which might well have been included in the major writeups, more could have been said about the way in which populations of the several species fit together in occupying available nest sites, in sharing predation pressures, and in competing for food at the height of the nesting season. For example, the lateness of the nesting of the lesser black-backed gull is mentioned, but there is no explanation of the way in which this delay insures protection for the eggs and chicks by the developing vegetation, an important point made in the chapter "Breeding time in the gull colonies" in F. Fraser Darling's remarkable little book, *Wild Country* [Cambridge University Press (1938), pp. 47–55].

Most of the errors in *Sea Birds* are minor. But some of them must be mentioned lest readers be led astray. The lovely "lesser black-backed gull" shown in color on page 117 is actually a great black-backed gull (*Larus marinus*), as careful comparison with specimens will show. The black-and-white photograph of a great black-backed gull on page 132 is correctly identified. The two photographs, though not necessarily of the same individual bird, were taken at the same nest. The lesser black-back (*L. fuscus*) is decidedly more slender of bill and less slaty on the back than the bird shown in either of these two photographs. The statement to the effect that procellariiform birds "can only shuffle slowly and clumsily about on their tarsi" (page 35) does not apply to the albatrosses, a small but important procellariiform family (Diomedeidae). The eye of the adult gannet is not gray (page 68) but pale yellow (see frontispiece). Evidence of very poor translation or of careless proofreading is the phrase "carmine-pink gills" which should read "carmine-pink bills" (page 87).

GEORGE MIKSCH SUTTON
Department of Zoology,
University of Oklahoma

Plasma Physics. James E. Drummond. McGraw-Hill, New York, 1961. xiv + 386 pp. Illus. $12.50.

Although the prospects for developing practical sources of thermonuclear energy seem remote, vigorous research programs in the field have excited considerable interest in plasma physics. It is only within the past few years that a full appreciation of the complexity of the plasma state has been achieved and exploited in the laboratory. This volume contains a collection of survey articles on recent advances in the field. All the articles are on a high technical level.

The introductory chapter on plasma oscillations (by Drummond) contains an interesting historical review and an unusually complete list of important publications on the subject. There follows the volume's *pièce de résistance*—a long article by Klimontovich and Silin on the spectra of systems of interacting particles. The authors pay particular attention to quantum mechanical questions and recent statistical mechanical considerations of collective effects; thus, they introduce a more fundamental approach to microscopic phenomena than is usually found in the literature. They also discuss the energy losses of charged particles which are able to excite collective oscillations in passing through a medium. Again, the bibliography is a valuable one.

Other papers include an excellent account of the results of the application of diagrammatic perturbation methods to equilibrium statistical mechanics (written by Meeron) with particular attention to the current status of Debye-Hückel theory; accounts of the classification of amplifying and decaying waves in plasmas (by Sturrock and Buneman); a review of magnetohydrodynamics with a discussion of some aerodynamic problems (by Yoler); and articles written on the Bennett pinch, the stability of relativistic self-focusing streams, and on topics relating to microwave interactions with plasmas.

Space does not allow a complete treatment of all the papers in this volume, but they are all at a uniformly high level. I wish that astrophysical plasma phenomena had been discussed and that the same level of generality had been maintained throughout the book. However, these are minor criticisms of an otherwise well executed venture.

GEORGE WEISS
University of Maryland

Developments in Mathematical Psychology. Information, learning, and tracking. R. Duncan Luce, Ed. Free Press, Glencoe, Ill., 1960. 294 pp. $7.50.

This volume surveys three areas of recent emphasis in mathematical psychology: information, learning, and tracking. It should have been published about 5 years ago when most of it was written. Many portions are condensed and fragmentary, in the manner of contemporaneous reporting such as is found in the *Annual Review* series. Fortunately, other portions are more didactic and render the volume useful in spite of the time lapse.

The article on information is by R. Duncan Luce; it is divided about evenly between a section on theory, in the Shannon-Wiener tradition, and a section on applications, addressed to many topics in psychology. The section on theory seems rather advanced for a beginner, yet rather sketchy for a professional. An asset is the inclusion of some interesting developments by G. A. Miller, W. R. Garner, and other behavioral scientists, which appeared in the wake of the famous Shannon and Wiener treatments. The section on applications runs the gamut from studies that are direct consequences of information theory (for example, statistical approximations to English) to studies that show little influence beyond an exchange of digital counts for logarithms to the base 2. There is also a sensible treatment of whether or not information theory really earns its keep in behavioral science.

The article on learning, by R. R. Bush, seems particularly out of date. Unlike the other two topics, learning is a central concern in general experimental psychology and has attracted many new efforts, mathematically oriented and otherwise. Bush himself has done later work that contributes to the obsolescence of his article. The presentation is organized as it should be to point up the substantive content of learning research: acquisition, extinction, generalization, and so forth. Models of the Bush-Mosteller variety receive primary emphasis, with the Estes-Burke approach running a close second. Hull is relegated to an appropriate place in history, but there is little indication of later developments by the Hullian school. The article seems just right for a specializing student of learning, who can profit from its many pertinent observations without depending upon it as an overview of the field.

J. C. R. Licklider did the article on tracking, a slice of engineering psychology in which the engineering is far more conspicuous than the psychology. Studies of tracking generally view the human operator as a component in a man-machine system, whose stimuli are mathematically describable inputs from the system and whose motor responses are similarly describable outputs. The Licklider article does well at placing the results of tracking experiments in their appropriate mathematical context. The context itself is developed from the ground up in the first ten pages only; beyond that there is a too-rapid cascading of much that is standard mathematical background for the engineer but not for the psychologist. Well-educated engineers should find the going easy and the treatment informative.

In spite of the limitations indicated, the volume as a whole will probably serve to acquaint a wider audience with some major developments of the past decade. It is welcome.

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Nuclear Forces and the Few-Nucleon Problem. vol. 1 and vol. 2. T. C. Griffith and E. A. Power, Eds. Pergamon Press, New York, 1960. xx + 712 pp. Illus. $30.

As channels for disseminating scientific information, conference proceedings published in book form, are problem children. A scientific conference itself has, in the order of their importance, three aspects, for it enables participants to discuss their work, to hear about the newest developments in the field, and perhaps to hear some general lectures. Thus the most important aspects of a conference—the private discussions between conference participants and the reports on the latest developments—are either not available for publications (the private discussions) or they should be published quickly while the "recent" developments reported still deserve to be called "the latest" (many papers will be published after the conference in the scientific journals). Conference proceedings should, therefore, be published as rapidly as possible in order to report fully on the newest developments in the field. Unfortunately the proceedings under review are the report of a conference held over 1½ years ago (July 1958). Thus, it is to be expected that their novelty value will be somewhat worn. This cannot be denied. But a considerable amount of information is contained in the volumes, and an appreciable fraction of it is up to date.

A major portion of the conference was devoted to the nuclear two-body problem. There were introductory lectures on the phenomenological description of the forces by phase shifts and by potentials, on the meson theory of the nuclear forces, on the dispersion relation approach to nuclear forces, and on the experimental status of the nucleon-nucleon interaction.

Furthermore, there were several papers summarizing the work of particular groups and an assortment of shorter reports on experimental and theoretical aspects of the two-body problem. The three- and four-body problem is treated in a large number of shorter papers. Also, more or less extensive treatment is given to the scattering of all pairs of particles with mass between two and four. Finally there are a few papers on the binding energy of some nuclei up to O^{16} as well as some other contributions.

Workers in the field, especially new-

comers, may find it useful to have everything collected and easily accessible, even though a large fraction of the papers have already appeared in the scientific literature. The informal character of the lectures may make this material easier to digest than the corresponding papers published elsewhere.

The editors and publishers have done a beautiful job. Still, I think that speed of publication should be the prime consideration in publishing conference proceedings, and I would gladly sacrifice everything except accuracy to this goal.

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Stars and Stellar Systems. vol. 6, *Stellar Atmospheres.* Jesse L. Greenstein, Ed. University of Chicago Press, Chicago, Ill., 1961. xix + 724 pp. Illus. $17.50.

It has been more than a century since Auguste Comte gazed into the clouded crystal ball and prognosticated: "There are some things of which the human race must remain forever in ignorance, for example, the chemical constitution of the heavenly bodies." We now know, thanks to spectroscopy, that these same heavenly bodies provide us with an infinite variety of strange, experimental, chemical and physical laboratories and that the detailed analysis of electromagnetic radiation originating in *stellar atmospheres* has led to fundamental discoveries far beyond anything that Comte could have envisioned.

The astronomer's approach is primarily an empirical one; first comes the observation which poses a problem that, later, demands theoretical interpretation. New observational knowledge also suggests new observational problems and techniques. The 1961 sun bears little resemblance to the 1941 sun because of new instruments such as the coronagraph, the rocket-borne spectrograph, and the radio telescope. One can predict with confidence that the 1981 stars —and their atmospheres—will be quite different from the 1961 stars, as new space observatories and radio telescopes explore great regions of the electromagnetic spectrum virtually untouched at the present time. Astronomy will continue to be the science of discovery.

This book is one of the first two volumes to appear of a proposed nine-volume "Compendium of Astronomy and Astrophysics" under the general editorship of Gerard P. Kuiper and Barbara M. Middlehurst. The aim of the compendium is to present stellar astronomy and astrophysics as basically *empirical* sciences, coordinated and illuminated by the application of theory. This compendium is intended as an extension of the four-volume "Solar System" series, edited by Kuiper.

Chapters 1 through 5 outline standard methods of theoretical analysis of stellar atmospheres. The next three chapters deal with nonthermal phenomena, magnetic stars, and stellar rotation and turbulence. Chapters 9 through 11 discuss high luminosity stars and extended atmospheres, while the last eight chapters are concerned with composite spectra, long-period variables, red giants, mass loss from red giants, isotopes, novae, dwarf variables, and stars below the main sequence. The normal red dwarf, by far the commonest type of star in space, is, strangely, not discussed.

The choice of both authors and subject matter is excellent, and there is no question but that this well-edited volume will be the primary authority in its field for many years. As such, it should have a profound influence in the training of the many needed future astrophysicists. The price is refreshingly low for a book of this size and quality.

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New Books

Mathematics, Physical Sciences, and Engineering

Industrial Organic Nitrogen Compounds. Melvin J. Astle. Reinhold, New York; Chapman and Hall, London, 1961. 399 pp. $14.

Information Retrieval and Machine Translation. pt. 1. Allen Kent, Ed. Interscience, New York, 1960. 701 pp. Illus. $23. First part of a two-volume work which will record the papers and discussions of the International Conference for Standards on a Common Language for Machine Searching and Translation, September 1959.

Integral Quadratic Forms. G. L. Watson. Cambridge Univ. Press, New York, 1960. 155 pp. $5.

Kinetics and Mechanism. A study of homogeneous chemical reactions. Arthur A. Frost and Ralph G. Pearson. Wiley, New York, ed. 2, 1961. 414 pp. Illus. $11.

Linear Graphs and Electrical Networks. Sundaram Seshu and Myril B. Reed. Addison-Wesley, Reading, Mass., 1961. 325 pp. Illus. $9.75.

Manual of Cotton Spinning. vol. 2, pt. 1, *The Characteristics of Raw Cotton.* E. Lord. Textile Book (Interscience), New York; Butterworths, London, 1961. 345 pp. $8.50.

Materials for Nuclear Engineers. A. B. McIntosh and T. J. Heal, Eds. Interscience, New York, 1960. 382 pp. Illus. $11.85.

Mathematical Methods for Engineers and Technologists. P. I. Romanovskii. Translated from the Russian by M. Slater. T. Kövàry, Ed. Pergamon, New York, 1961. 265 pp. Illus. $8.50.

Matheson Gas Data Book. Matheson, East Rutherford, N.J., ed. 3, 1961. 438 pp. Illus. $8.

Mechanics of Solids and Fluids. Robert R. Long. Prentice-Hall, Englewood Cliffs, N.J., 1961. 166 pp. Illus. Trade, $9; text, $6.75.

Notes on Quantum Mechanics. A course given by Enrico Fermi. Univ. of Chicago Press, Chicago, Ill., 1961. 171 pp. Paper, $1.50. Lecture notes as prepared by Fermi for a course in early 1954.

NMR and EPR Spectrocsopy. By the staff of Varian Associates. Pergamon, New York, 1960. 296 pp. $12. A large part of the material presented at the third annual workshop sponsored by Varian, October 1959.

Optical Spectrometric Measurements of High Temperatures. Philip J. Dickerman, Ed. Univ. of Chicago Press, Chicago, Ill., 1961. 276 pp. Illus. $12.50. A series of papers and accounts of related discussions resulting from a symposium at the University of Chicago, March 1960.

The Philosophy of Physics. Vincent Edward Smith, Ed. St. John's Univ. Press, Jamaica, N.Y., 1961. 85 pp. Paper. St. John's Univ. Studies, Philosophical Series, 2.

Physical Chemistry. Farrington Daniels and Robert A. Alberty. Wiley, New York, ed, 2, 1961. 754 pp. Illus. $8.75.

Physical Gas Dynamics. A. S. Predvoditelev, Ed. Translated from the Russian by R. C. Murray and D. R. H. Phillips. Pergamon, New York, 1961. 187 pp. Plates. $7.50.

Physics and Archaeology. M. J. Aitken. Interscience, New York, 1961. 191 pp. Illus. $6.

Polynomials Orthogonal on a Circle and Interval. Ya. L. Geronimus. Translated from the Russian by D. E. Brown. Ian N. Sneddon, Ed. Pergamon, New York, 1960. 219 pp. $8.50.

Polypropylene. Theodore O. J. Kresser. Reinhold, New York; Chapman and Hall, London, 1960. 280 pp. Illus. $6.50.

Porcelain Enamels. The preparation, application, and properties of enamels. Andrew I. Andrews. Garrard Press, Champaign, Ill., ed. 2, 1961. 659 pp. Illus. $12.

Radiation Protection and Recovery. Alexander Hollaender, Ed. Pergamon, New York, 1960. 397 pp. Illus. $10.

Transistor Circuit Analysis. Maurice V. Joyce and Kenneth K. Clarke. Addison-Wesley, Reading, Mass., 1961. 475 pp. Illus. $10.75.

Reports

Occurrence of Titanium, Vanadium, Chromium, and Sulfuric Acid in the Ascidian Eudistoma ritteri

Abstract. The body tissues of the colonial ascidian *Eudistoma ritteri* are shown by quantitative spectrographic analysis to contain up to the following amounts of related metals (parts per million of dry weight): titanium, 1512; vanadium, 471; and chromium, 144. Body tissues and tunic fluid show a *p*H of 1.5 due to the presence of sulfuric acid.

Half a century ago Henze demonstrated the presence of relatively high concentrations of vanadium in phlebobranch ascidians and found this to occur in certain blood cells in association with high concentrations of sulfuric acid (*1*). Since that time numerous workers have confirmed the presence of vanadium in blood cells or other tissues of ascidians and have noted that relatively high concentrations appear to be restricted to certain members of the ascidian order Phlebobranchiata (*2*, *3*).

The more recent discovery of 475 ppm of vanadium in *Euherdmania claviformis* (*4*) and the reports of positive tests for vanadocytes in *E. claviformis* and *Pycnoclavella stanleyi* (*5*) are of particular interest, for they constitute the first indications of comparably large concentrations of vanadium, and of the presence of vanadocytes, in any members of the ascidian order Aplousobranchiata. It seemed desirable that other species among the less specialized aplousobranchs should also be examined for vanadium content. Further, the reports of quantities of manganese in several ascidians (*6*, *7*), the discovery that individuals of *Molgula manhattensis* may concentrate either vanadium or niobium (*8*), and the finding that *Pyura stolonifera* accumulates iron (*9*), suggested that other related metals might also be present in ascidians.

Eudistoma ritteri Van Name, 1945, represents a relatively unspecialized aplousobranch ascidian common along central California shores. Initial tests for vanadium in *E. ritteri* included microscopic examination of the blood for vanadocytes and treatment of the blood cells and other tissues with osmic acid and neutral red by the diagnostic tests of Webb (*2*) and George (*10*). The blood shows an abundance of morular "green-cell" corpuscles, which, however, fail to exhibit the characteristic staining reactions of vanadocytes; they neither take up neutral red nor darken in the presence of osmic acid. However, these tests proved positive when applied to other body tissues. The entire epidermis concentrates neutral red heavily; the whole body blackens in the presence of osmic acid. The fluid of the tunic has a *p*H of 1.5 as shown by a glass-electrode *p*H meter and indicator papers specific for low *p*H. When $BaCl_2$ is added to the tunic fluid, a heavy precipitate of $BaSO_4$ is formed, indicating the presence of sulfuric acid.

Chemical analyses of the tissues for vanadium were carried out with the phosphotungstic acid method described by Sandell (*11*). The bodies of approximately 1500 to 2000 zooids were removed from living colonies, inspected to insure that digestive tracts were empty of food and feces, dried at about 110°C, weighed, ashed at 600°C, and tested. The phosphotungstic acid method yielded rather erratic results, suggesting the presence of one or more elements, such as titanium, which are known to interfere with the test for vanadium in this method.

Samples of zooids, dried and ashed as before, were subjected to quantitative spectrographic analysis (*12*). The results, shown in Table 1, indicate that titanium is present in quantities of up to 1512 ppm, vanadium in amounts of up to 471 ppm, and chromium in amounts of up to 144 ppm in dried, whole, unpreserved zooids. The vanadium concentration in the lower abdomen is greater than that in the zooid body as a whole. Zooids preserved in 10 percent neutral formalin for 4 years show roughly similar quantitative relationships between the three metals, but the concentration of each is drastically reduced. Spectrographic analysis of salt formed by evaporating sea water collected from the immediate environment of *E. ritteri* indicates that these three metals are below the level of detection.

The concentrations of vanadium reported here are similar to those obtained in *Euherdmania* (*4*). Titanium has previously been reported from ascidian tissues (*6*) only in trace amounts (1.7 ppm dry weight). Chromium has not been reported to be concentrated by ascidians according to my present knowledge.

The metals now known to be accumulated in relatively large amounts by some ascidians show the following arrangement relative to one another in the periodic table:

Ti V Cr Mn Fe
Nb

All belong to the "related metals" class and have a similar number of electrons in the outermost and the next-to-the-outermost shells. Manganese has been reported by I. Noddack and W. Noddack (*6*) to be concentrated by *Ciona intestinalis* at 120 ppm of the dry weight, and Vinogradov (*7*) reports "large quantities in *Didemnum albidum* and *Microcosmus glacialis* which have $CaCO_3$ spicules."

The function of vanadium in ascidians remains uncertain. However, the chemical similarities among at least some of the substances listed suggests the possibility that these metals may play more or less interchangeable physiological roles. The findings of Carlisle (*8*) further suggest the possibility that small genetic or physiological differences, even within a single species, may favor the concentration of one or another of these elements. The presence of relatively great amounts of vanadium in both *Euherdmania* and *Eudistoma* indicates that, in this feature, these genera are more closely allied to the ascidians of the order Phlebobranchiata than to the aplousobranchs with which

Table 1. Quantities of titanium, vanadium, and chromium in spectrographically analyzed samples of *Eudistoma ritteri* zooids removed from the tunic (parts per million of dry weight).

Unpreserved zooids		Whole preserved zooids	Sea water salt
Whole	Abdomens only		
	Titanium		
1361–1512	1110	529	0
	Vanadium		
370–471	660	18	0
	Chromium		
72–144	100	2	0

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

they are generally placed. This provides further evidence to support the contention of Berrill (*13*) and others that the polycitorid aplousobranchs (*Eudistoma* and close allies) have clear affinities with the diazonid phlebobranch ascidians. Further studies of the distribution of metals in ascidians are continuing (*14*).

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13. N. J. Berrill, *Phil. Trans. Roy. Soc. London Ser. B* **226**, 43 (1936); *J. Morphol.* **81**, 269 (1947).
14. This report is a portion of a thesis submitted in partial fulfillment of the requirements for the Ph.D. degree at Stanford University. Thanks are due to D. P. Abbott of the Hopkins Marine Station for advice and encouragement during the work.
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9 January 1961

Wave-Guide Modes in Retinal Receptors

Abstract. Retinal receptor wave-guide modal patterns have been photographed. The inner and outer segments of the rod and cone receptors of albino rats, rhesus macaque monkeys, and human beings have been studied. The wave-guide modal pattern is believed to be the normal form of energy transfer in these parts of the retinal receptors in these species.

Since 1933, when Stiles and Crawford (*1*) discovered the directional sensitivity of the retina, increased interest has been directed toward the optical properties of the retinal receptors. In the past few years, with the rapid development of fiber optics, the retinal receptors have been viewed with interest because they are, in fact, a functioning and highly efficient fiber bundle. That is, the resolution capacity of the retina is essentially limited in the fovea by the diameter of the individual receptors (*2*).

Inasmuch as the diameters of the components of the receptors begin to approach the wavelength of light, it has been assumed that the inner segment, ellipsoid, and outer segment of the retinal receptors act as dielectric wave guides (*3*). If this assumption is accepted, it then becomes logical to look for, identify, and determine the role played by wave-guide modal patterns in the retinal receptors. At this time, wave-guide modes have been seen (*4*), they are being identified under various conditions, and first thoughts have been given to the possible roles they play in the visual mechanism (*5*).

Electromagnetic waves are guided in a wave-guide. The modal pattern shown in Fig. 1 is the result of interactions which have occurred in the receptor acting as a wave guide. A wave-guide modal pattern may be defined as a distribution of field which propagates down a wave guide with a well-defined phase velocity. These patterns result in a nonuniform distribution of energy in the receptor.

While the apparatus needed for visualization of these modal patterns is rather simple in principle, the accomplishment of the goal presents serious problems. In essence, one creates a schematic eye with a piece of retina placed in a special chamber (in normal saline) and oriented as it might be *in situ*. An intense source of light is imaged by a lens upon the retinal tissue. Since a modal pattern may change when the wavelength, the angle of incidence of the luminous energy, or both the wavelength and angle of incidence are varied, it is useful to control the wavelength composition of the light and to insert a diaphragm (analogous to the iris of the eye) to limit the angular subtense of the incident cone of light. A microscope is situated above the flat retinal preparation, and hence one observes the light which has passed through the receptors. The limiting resolution of the microscope, the maintenance of receptor orientation, the elimination of vibration effects during time exposures, the graininess of the film, and the need for rapid dissection of the specimen present the major problems to the investigator.

Similar wave-guide modal patterns have been observed by focusing upon the outer segments of the receptor of albino rat, rhesus macaque monkey, and human retinas. All receptors studied exhibited the mode form of energy transfer. An example of such a pattern recorded from a cone receptor located in the macula area of a monkey is shown in Fig. 1.

In some receptors the perceived modal pattern changes when wavelength is varied. The patterns also often change when the focal plane within the receptor is varied. In any given mosaic

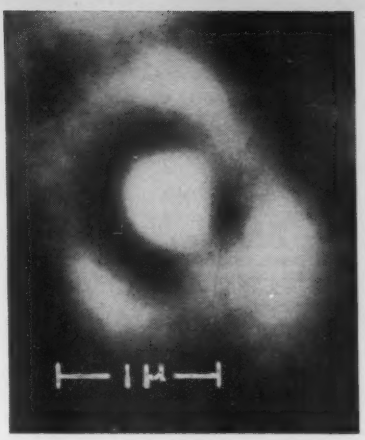

Fig. 1. A wave-guide modal pattern recorded from the outer segment of a cone in the macula of a monkey.

of outer segments a dominant modal pattern is seen. Some departures from the dominant pattern are due to differences in diameters, cross-sectional shape, and orientation. In all three species, when the outer segments of the receptor were viewed, only a small number of different patterns were seen. When the pattern changed as wavelength was varied, only one or two changes occurred within the range of 450 μ to 600 mμ. Rods and cones may be readily differentiated in monkey and human retinas. In some receptors modal patterns vary in the intensity of their excitation, their transmissivity as a function of wavelength, or both. The directionality of the retinal receptors is readily observed.

The role(s) played by wave-guide modes in vision may be many fold. The differential transmissivity of modal patterns as a function of wavelength obviously influences the result. The modal patterns themselves give rise to regional nonuniformities in energy concentration in the outer segments of the receptor. It is important to know, particularly in receptors responsible for color vision, whether there are corresponding nonuniformities in pigment concentration (and how many pigments are involved), or in potential to evoke a response. It also becomes necessary to explore further electro-physiological and psychophysical correlates.

At this time it can be said that the wave-guide mode form of transmission is probably the normal form of energy transfer in these species, and that the response of a given receptor may be modified by the presence of the mode form of transmission (*6*).

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6. This research was supported in part by grant B-2168 from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service. I would like to express my appreciation to E. Snitzer for his advice on several phases of this work.

29 November 1960

Does the Male Stimulate Oestrogen Secretion in Female Canaries?

Abstract. Female Border canaries treated with oestrogen during the nonbreeding season may build nests, regardless of winter lighting, temperature, and absence of partner. Incubation may follow completion of the nest although ovulation is suppressed. Reactions obtained in the breeding season suggest that the male does not initiate but accelerates oestrogen production through the stimulation he provides.

In seasonally breeding birds cyclical aspects of the environment have been associated with periodic changes in the gonads (*1*). It is also well known that the sequential changes in breeding behavior depend on changes in the hormonal state (*2*). The sequence of physiological and behavioral events does not depend on one environmental factor, but on several which occur simultaneously or in succession. Thus increasing day-length, a prime factor in inducing gonadal growth in many temperate zone species (*3*), may be less effective unless other changes also occur.

One factor of importance is the interaction between male and female (*4*): for example, stimuli from the male are important in inducing ovulation in female pigeons (*5*). In domesticated canaries nest building and egg laying in the spring are delayed when females are kept visually isolated from males (*6*). Since nest building can be induced by injections of oestrogen (*7*), it therefore seemed probable that one function of the male is to accelerate oestrogen production in the female. If this is the case, the presence or absence of the male should not affect the occurrence of nest building if the level of oestrogen is controlled. Accordingly, equal quantities of oestrogen were administered during the nonbreeding season to female canaries (i) kept in visual isolation from males, (ii) paired with untreated males, and (iii) paired with males treated with androgen.

Canaries were of the Border variety, purchased from a dealer. Eighteen females and twelve males were used. Three groups of birds were set up as follows: Group A, six females housed individually and visually isolated from other birds. Group B, six females each paired and housed with an untreated male. Group C, six females each paired and housed with a male receiving 2.0 mg of testosterone propionate three times a week.

All females in each group were given 0.5 mg oestradiol benzoate (oestroform aqueous BDH) in 0.05 cm^3 of solution injected into the pectoral musculature thrice weekly.

Each cage was supplied with a felt-lined nest pan as a nest site. Two baskets of nesting material, one containing grass and the other feathers, were hooked to the outside of the cages. The baskets were so arranged that the birds could peck out grass or feathers at will. The supply of grass and feathers was replenished daily or when needed.

Birds were killed after the experiment to be sure of sex identity. The oviducts of the first four birds that completed nests regardless of group were compared with those of birds from the same group which had had an equal number of oestrogen injections but did not build.

The testosterone-treated males, unlike the untreated ones, were seen to sing, show courtship behavior, and mount. No attempt to compare quantitatively their sexual activity with that of males in the spring was made.

There were no apparent differences between groups in the nest building behavior of the females, or in the interval between the start of oestrogen injections and the occurrence of nest building. The results for each group were as follows:

Group A (isolated females). Four out of six showed building activity. Three of these built good nests. The fourth built an incomplete nest and was found to be a male on autopsy. Of the three females, each had four injections prior to the start of nest building (that is, before several scraps of nest material were found in the nest). Nests were completed in 7, 7, and 9 days from the start of building. The bird which took 9 days incubated the eggless nest when it was complete.

Group B (females with untreated males). Three out of six showed nest-building behavior after two, seven, and eight injections, respectively. Only one bird completed a nest, 15 days from the start of building activity. The other two nests were not completed. The bird that completed construction also incubated the eggless nest.

Group C (females with testosterone-treated males). Two of the six females started to build, one after the fourth and the other after the sixth injection, and completed nests in 6 and 5 days, respectively. Only the latter bird incubated.

Although only about half of the birds in each group built nests, resistance to exogenous oestrogens, especially with respect to behavioral effects, has frequently been reported elsewhere (*8*). Indeed, the quantity of hormone required to induce nest building under the conditions of this experiment cannot be withstood by some individuals (*7*). That the oestrogen was effective in influencing reproductive accessories even when it did not induce nest building was shown by observations of oviduct weight. Table 1 shows that these were comparable for birds that did and did not construct nests after equal numbers of injections.

These results indicate that during the nonbreeding period exogenous oestrogens will cause female canaries to show nest-building behavior with equal rapidity whether they are paired with a male or not, even if the male is showing courtship behavior. Thus neither the visual presence of the male, nor the temperature and light conditions of spring, are necessary for nest-building activity, providing certain levels of oestrogen are reached. These results thus support the view that, during the breeding season, the male acts together

Table 1. A comparison of the weights of oviducts after 11 oestrogen injections between birds that did (first four birds) and did not build nests. Groups A, B, and C represent females in isolation, with untreated males, and with treated males, respectively.

Group	Built nest			No nest		
	Females (No.)	Oviduct weight (mg)	Body weight (g)	Females (No.)	Oviduct weight (mg)	Body weight (g)
B	30	304	21.6	12	404	21.6
A	31	454	20.1	27	220	20.8
C	33	284	20.5	1	370	24.0
A	22	325	22.0	28	424	23.2

with other environmental changes to elevate oestrogen levels in the female. The fact that some females may eventually build nests in the spring without a male (*6*) suggests that the male does not initiate oestrogen production, but rather accelerates it so that levels sufficient to ensure nest building are reached early in the season.

Since exogenous oestrogen restricts hypophyseal secretion of gonadotrophins and thereby suppresses ovarian growth, the birds treated with the hormone did not lay eggs after nest building. However, one bird from each of the treated groups showed incubation behavior after completion of the nest. Incubation is easy to identify because, once it is firmly established, the female can actually be picked out of the nest; birds which are not incubating rarely sit in the completed nest, and if they do they fly from the nest as soon as the cage door is opened or a hand approaches them.

This incubation of the eggless nest indicates that eggs or egg-substitutes are not essential for incubation to occur. Nor is ovulation a *sine qua non* for incubation. That nest construction is not a prerequisite for ovulation has previously been shown. In the spring birds may ovulate (albeit delayed beyond the normal period), if they are prevented from building nests, and may even show incubation behavior (*9*).

Proper timing of the physiological changes associated with the successive phases of reproduction is essential for successful breeding. If young are to be raised and fledged at the biologically correct time, the proper hormonal states must occur appropriately. It is clear that none of these changes depend on single factors—rather, in each case a number of factors act synergistically to promote the next stage. In the absence of all the appropriate factors, those present may be effective if they continue to act over a long period. Thus incubation may occur without ovulation and even without a nest (*10*).

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27 December 1960

Specificity of Discrimination Learning to the Original Context

Abstract. Rats learned a black-white discrimination at one location in a maze. Subsequently, most rats required over half as many trials to learn the same discrimination when it was placed in another location in the maze. Additional evidence was consistent with the assumption that the relevant cues are, in effect, modified by interaction with the contextual stimuli.

The fact that a change in the background contextual environment produces some disruption in the performance of learned behavior is widely recognized. However, there are not many clear-cut demonstrations of this fact, particularly in a laboratory setting. The purpose of this report is to describe a striking and somewhat unexpected instance encountered during research designed for other purposes.

Rats were being run in a maze whose floor plan is shown in Fig. 1. As depicted, if the rat turned to the right after leaving the start box, it would take two additional right turns and then arrive at a second choice point displaying a black-white discrimination problem. That is to say, reward at the goal was contingent on the rats' selecting, let us say, the black swinging door regardless of its position at that choice point.

If, alternatively, the rat turned to the left after leaving the start box, it would take two additional left turns and then be forced to take a left (or, on half of the trials, a right) turn through a grey swinging door. Frequency of reward in this case was matched to the level of success on the discrimination problem. Specifically, when early in training the rats had strong position preferences at the discrimination choice point, so that they were obtaining reward on that half of the trials when the positive cue was in their preferred position, they were also rewarded on half the trials in the other wing of the maze. Subsequently, as the rats mastered the discrimination problem in the right wing of the maze, the reward frequency in the left wing rose correspondingly. Throughout, the reward was arranged so as to be nondifferential with respect to position at any choice point.

The data of immediate interest arose when, in order to evaluate the strength of the general preference for the nondiscrimination wing of the maze, the location of the discrimination was changed to the left wing of the maze. It was expected that, after perhaps a slight disruption, the animals would transfer their previous learning. As will be seen, however, the degree of transfer was small.

Eight hooded rats were run on the problem schematized in Fig. 1, some with white positive and some with black, and some with the discrimination in the right wing and some with it in the left wing. The maze was illuminated by six 7-watt bulbs spaced equally 1 foot above the maze to minimize differential extra-maze cues. The rats were run after 23 hours' deprivation on a 12 g/day maintenance schedule and were given four 45-mg pellets as reward when appropriate. Both free and forced trails were given at the first choice point to equate the number of runs in each wing. All trials at the discrimination choice point were free, and all trials at the nondiscrimination choice point were forced in such a way as to insure equal and nondifferential reinforcement. The number of trials given in the original problem varied, but all rats used in the experiment had attained a criterion of 15 correct choices out of 16 at the discrimination choice point before its location was changed to the opposite wing.

One rat showed essentially perfect transfer in that it met the above criterion in its first 16 trials with the discrimination in its new location. The other rats, however, adopted position responses, their savings scores being 56, 32, 31, 28, 19, 15, and 13 percent. The median number of trials to learn the original discrimination was 424. The median number of trials to learn the same discrimination in its new position was 280.

Two somewhat different (though not incompatible) interpretations of the role of context might be advanced to account for this finding. According to one, contextual stimuli interact with the relevant cues, modifying them by patterning so that a change in context changes the pattern and hence disrupts performance. That is to say, a white door in the right wing of the maze is different from the same white door in the left wing, and there is a generalization decrement when shifting from

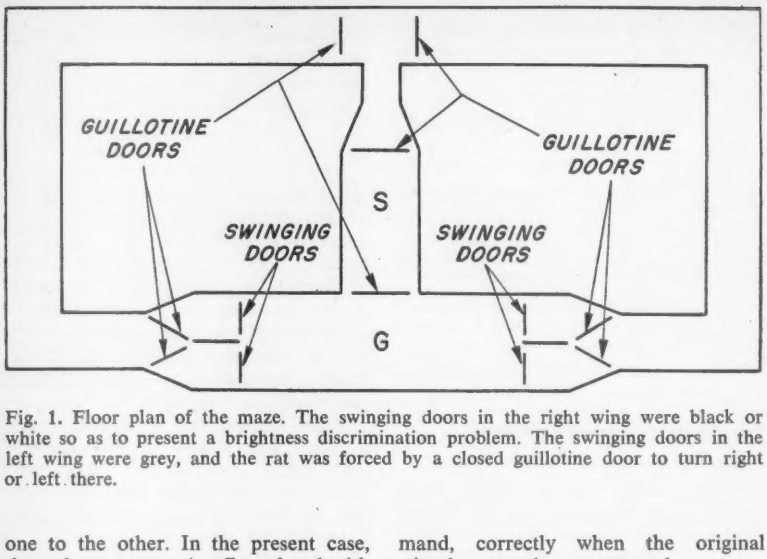

Fig. 1. Floor plan of the maze. The swinging doors in the right wing were black or white so as to present a brightness discrimination problem. The swinging doors in the left wing were grey, and the rat was forced by a closed guillotine door to turn right or left there.

one to the other. In the present case, then, the rats were, in effect, faced with a different discrimination problem.

The second interpretation assumes that discrimination learning requires, at least in part, that the subject learn to look at, attend to, or perceive the relevant cues, and the role of context is to elicit these perceptual responses. In the present case, then, the context in the left wing had not trained the rat to attend to the brightness of the doors; indeed, any such tendency generalized from the right wing would have been extinguished because brightness was not differentially reinforced on that side.

Three additional observations bear on these conceptions. First, the perceptual approach could handle very sudden learning of the discrimination in its new location because, once the perceptual response came in, the subject could perform perfectly the task he had previously solved. In fact, although the transition from position habit to correct preference was fairly abrupt, it was not noticeably more so in the new location than it had been in the original location. All animals continued to err occasionally for a number of trials after they first broke from their preferred position, as would be expected from the patterning interpretation.

Secondly, according to the perceptual interpretation, attending to the brightness of the doors in the original wing would be extinguished during the reversal training because reward was no longer differential there. This would lead to a comparable difficulty in transfer during a second reversal when the discrimination problem again appeared in its original location. In fact, all of the five rats tested in this way transferred essentially perfectly, performing, as the patterning approach would demand, correctly when the original stimulus complex reappeared.

Finally, if rats are trained on the discrimination problem in the right wing without also being run in the left wing, then the perceptual approach could account for near-perfect transfer when the rats first run and encounter the discrimination problem in the left wing. This derivation assumes that the attending response should generalize and would not have been extinguished by nondifferential reinforcement. In fact, three rats run through this sequence had transfer scores of 78, 72, and 51 percent. These scores, while perhaps somewhat larger than those obtained after the original procedure, are in line with what one would expect from the patterning approach, since the stimulus change should be essentially the same in either case, but the original procedure should make it somewhat more difficult to break up position preferences.

It should be clear that these results do not show that perceptual behavior is not involved in this type of discrimination situation, and certainly conditions could be devised that would require characteristic receptor-orienting behavior in particular contexts. The results do show that position preferences are not eliminated by extensive nondifferentially reinforced forced occurrences of the alternative responses, and they are generally consistent with the assumption that the relevant cues in a discrimination interact with the contextual stimuli and are modified by this interaction in such a way that changing the context effectively also changes the relevant cues.

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28 December 1960

Perceived Movement in Depth as Function of Object Luminance

Abstract. Thresholds for the binocular and monocular perception of movement in depth for a circular stimulus object decreased as target luminance was increased to 0.1 ft-lam. Above 0.1 ft-lam little change in threshold was observed. Superiority of binocular over monocular conditions decreased with higher luminances.

This report deals with the ability of human subjects to perceive whether an object, viewed in an otherwise totally dark field, is approaching or receding as a function of the luminance of the object for various durations of observation under binocular and monocular viewing conditions. Renewed interest in this area of research results from an analysis of anticipated visual skills required in certain manned space vehicle operations. The stimulus object was a circular, electroluminescent lamp, 3.5 in. in diameter. It was mounted on a cart which traveled on tracks, either directly toward or away from the subject, at a constant speed of 3.3 in./sec. The stimulus lamp was energized when the cart supporting the target crossed a microswitch. At this point the stimulus lamp was 25 ft from the subject and subtended a visual angle of 40 min of arc. The angular subtense of the stimulus, depending on whether it moved toward or away from the subject, increased or decreased at an initial rate of approximately ½ min of arc per second. The lamp, depending on the experimental condition, had a luminance of 0.001, 0.01, 0.1, or 1.0 ft-lam. The nine durations of exposure used were 0.6, 1.2, 1.8, 2.7, 4.2, 6, 9, 13.2, and 19.8 sec. Only six durations were used for a given luminance condition, the shorter six durations being used for the higher luminance levels.

Four adult subjects with several hours of familiarization training in the task were used in a 4 by 4 Latin-square design. The subjects, run individually, were allowed to adapt to the dark for 15 min prior to an experimental session. Each experimental session consisted of 25 trials at each of six exposure durations for a given luminance and viewing (monocular or binocular) condition. An experimental session lasted about 90 min. Each subject had each luminance condition twice for each viewing condition, requiring a total of 16 sessions and yielding 2400 observations per subject.

The experiment was conducted in a light-tight room 50 by 20 ft with a 12-ft ceiling. The walls and ceiling were covered with a black matte flocking material to minimize reflected illumination. During the experiment the subject was seated in a booth and was provided

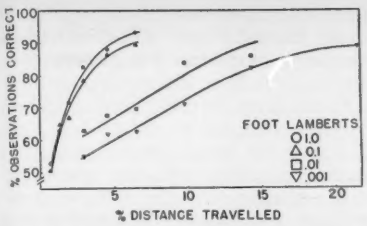

Fig. 1. Accuracy of detecting movement in depth as a function of the observed distance traveled for four luminance levels. The 50-percent value on the ordinate represents chance performance. The curves are the average for binocular and moncular conditions. Each point is based on 400 observations.

with a chin rest adjusted so that he could view the stimulus object through an aperture in the front of the booth. This arrangement provided direct visibility of the stimulus object in an otherwise totally stimulus-free visual field. The subject was alerted a few seconds prior to each trial presentation. The stimulus object then appeared for a controlled duration. The subject responded with a two-way throw switch to indicate whether the object appeared to approach or recede. Subjects were not informed of the correctness of their responses. A two-category, forced-choice method was used—that is, the subject had to respond with his best guess. The order of presentation (whether the object approached or receded) was selected from a table of random numbers, but was controlled so that each condition appeared an equal number of times.

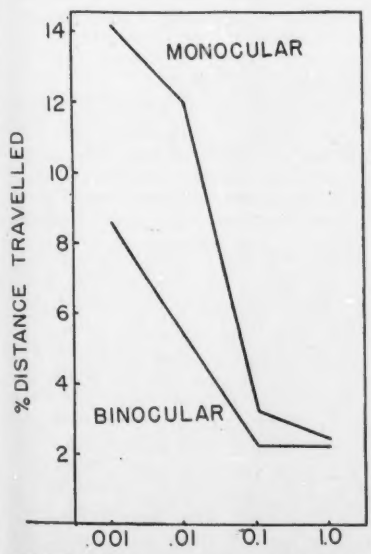

Fig. 2. The percentage distance traveled required for 75-percent correct detection of movement in depth as a function of luminance level for monocular and binocular viewing conditions.

Some of the results showing the percentage of correct observations as a function of the percentage of the original distance traveled for the four luminance levels used in the study are presented in Fig. 1. The percentage distance traveled is directly proportional to observation duration and, for the range of values involved, it approximates percentage change in visual angle subtense of the stimulus object. The curves shown are the average curves for both binocular and monocular vision. The 50-percent value on the ordinate represents chance performance, since with no information the subject, by guessing, would be correct about 50 percent of the time.

The data shown are for the average of the measures for conditions when the stimulus approached and receded. Although each condition occurred an equal number of times, on 51.9 percent of the observations the subjects reported that the object was approaching. This small, though statistically significant bias, may indicate that when the object approached, the movement in depth was more easily perceived than when it receded for any given observation duration. This would be expected because a slightly greater visual angle change occurs per unit time when the object is approaching than when it is receding. Also, there may have been a response preference independent of the stimulus conditions which would account for this small bias.

Figure 2 presents the percentage distance traveled required for 75-percent correct detection of movement in depth as a function of luminance for monocular and binocular viewing conditions. The percentage distance traveled required for 75-percent correct detection decreases with increasing luminance up to 0.1 ft-lam. The further luminance increase to 1.0 ft-lam does not affect binocular performance and only slightly lowers thresholds for monocular performance. This finding is in general agreement with studies of other visual functions as they relate to luminance (*1*).

The marked superiority of the binocular over the monocular viewing condition for the lower luminances is not easily accounted for. Since no other stimuli were in the visual field, disparity cues were not present and convergence cues could contribute very little, if any, information for the viewing distances involved. The only reasonable cue available for discriminating the movement in depth was the change in retinal image size in time. Conceivably, binocular summation of the stimulus energy could account for at least part of the superiority of the binocular condition at the lower luminance levels (*2*). Smith (*3*) found a definite superiority for binocular over monocular viewing in a similar visual task. However, Smith used luminance levels in the order of the higher levels used in the present study, and at these luminance levels binocular summation of energy should contribute little, if any, improvement. An analysis of the superiority of binocular over monocular visual acuity has been reported elsewhere (*4*).

No improvement in performance was evident with the practice afforded during the course of the experiment. The intersubject variability in the performance of this task was considerable at the lower two luminances, but was small for the higher two luminances.

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23 February 1961

Auxin Gibberellic Acid Interaction in Controlling the Hypocotyl Growth in Seedlings

Abstract. High concentrations of indole-3-butyric acid, when applied at a concentration of 100 to 200 parts per million (ppm) to presoaked seeds, cause a marked inhibition of hypocotyl length in the seedling growth of *Phaseolus mungo* var. T-2. Gibberellic acid, when applied at a concentration of 5 ppm, quantitatively reversed this inhibition. It is suggested that the interaction between these two growth substances controls the morphogenetic differentiation in regard to hypocotyl formation in seedling growth.

Interactions of growth substances are known to regulate the morphogenetic changes as the production of roots or buds in the tobacco pith callus tissue (*1*) and the growth of the preformed buds in the pea stem sections (*2*). Kuse (*3*) showed that both auxin and gibberellin were required for the growth of the petiole in the leaves of *Ipomea batatus* Cv. Norin No. 1, and Skinner *et al.* (*4*) brought forward evidence that interactions between gibberellins and substituted purines indeed control seed germination. The phenomenon of the different mode of seedling growth in different genera of the same plant

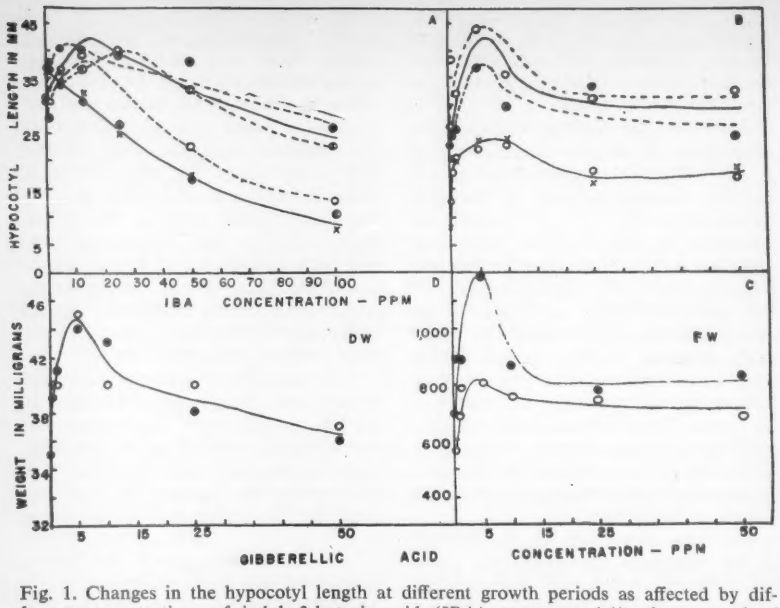

Fig. 1. Changes in the hypocotyl length at different growth periods as affected by different concentrations of indole-3-butyric acid (IBA) treatment (*A*), the reversal of inhibition in length caused by gibberellic acid with a concentration of 100 ppm of IBA (*B*), fresh weight changes (*C*), and dry weight changes (*D*). Curves marked with a single × and a circled ×, 3 days in two experiments; open circles, 4 days; circle with vertical line, 7 days; solid circles, 8 days. In *B*, the circled × has been used for 7 days.

family has not yet received the attention of the biologists. The reason as to how a pronounced hypocotyl is formed in certain cases carrying the cotyledons above the surface of the soil (that is, showing epigeal seedling growth) and how in other cases the cotyledons remain submerged inside the soil and the shoot emerges with its first leaves (that is, showing hypogeal seedling growth) has not yet been explained. Morphologically the hypocotyl region exists in the latter form, too, although much reduced (*5*).

The present investigation was undertaken when it was observed that, when seeds of *Phaseolus mungo* var. T-2 were treated with high concentrations of indole-3-butyric acid at a concentration of 100 to 200 ppm, there was a marked reduction of the hypocotyl—so much so that the seedlings in some cases appeared almost hypogeal in nature. The shortening of the hypocotyl was almost completely reversed by low concentrations of gibberellic acid, particularly at concentrations of 5 ppm.

Figure 1*A* shows the effect of various concentrations of indole-3-butyric acid on the length of the hypocotyl at various growth periods. Up to the third day after germination the increasing concentration of the acid showed an inhibitory effect on the length of the hypocotyl. From the fourth day onward, however, to the seventh and eighth days, the concentrations ranging from 1 to 25 ppm showed a promotive effect on the length of the hypocotyl over the control. This suggested that some substance produced by the cotyledons or the growing first leaves at this stage of growth interacted with the externally applied hormone to give this promotive effect and that during the first three days more auxin than the other substance was being produced so that the externally applied auxin raised this to the inhibitory level. If this were true, then the gibberellic acid alone, when given to the presoaked seeds, would give stimulation at the third day and no change or an inhibition of the hypocotyl length at the seventh or eighth day. This indeed has been found to be so. The application of gibberellic acid (GA_3) alone, given for 3 hours to the previously soaked seeds, gave values (in millimeters) on the third day as follows: control, 26.0 mm; 1 ppm GA_3, 27.7; 2.5 ppm GA_3, 29.1; 10 ppm GA_3, 17.4; 20 ppm GA_3, 21.3; and 50 ppm GA_3, 24.2. mm. On the seventh day the values were: control, 41.1; 1 ppm GA_3, 39.1; 2.5 ppm GA_3, 34.8; 10 ppm GA_3, 35.0; 20 ppm GA_3, 36.5; and 50 ppm GA_3, 40.0. Gibberellic acid indeed is known to give an additive effect with auxin in the growth of the pea stem sections (*6*). Higher concentrations of indole-3-butyric acid, like those of 50, 100, and 200 ppm showed marked inhibitions however.

A concentration of 100 ppm of indole-3-butyric acid was used as the inhibitory hormone concentration in further experiments for two reasons. First, this concentration did not result in the abnormal callus formation on the cotyledons, and, second, it was not toxic for the growth of the seedling and yet it resulted in marked inhibitions of hypocotyl length.

Figure 1*B* shows the effect of different concentrations of gibberellic acid when given to the seeds in combination with indole-3-butyric acid at a concentration of 100 ppm. The treatment was given for 3 hours. The results plotted are those obtained in two separate experiments. It will be seen that, although all the concentrations of gibberellic acid reverse the inhibition to a certain degree or the other, it is almost quantitatively reversed by a concentration of 5 ppm of gibberellic acid and at all the periods on which the growth measurements were made. Further it will be noted that the reversal has been almost complete not only in relation to length (Fig. 1*B*) but also in regard to the fresh and dry weights of the hypocotyl (Fig. 1, *C* and *D*).

Although the length of the hypocotyl is closely paralleled by changes in the fresh weight at 4 and 8 days of seedling growth, the dry-weight changes show an interesting result. Both the length and the fresh weight of the hypocotyl on the eighth day, in the case of 5 ppm of gibberellic acid given with 100 ppm of indole-3-butyric acid, is about 175 to 200 percent to that of the fourth day, the dry weight showing almost no change. This would indicate that growth during this period has been chiefly because of cell enlargement causing elongation of the cells of the hypocotyl and increase in the fresh weight; this indication fits in very well with the gibberellic acid effect.

The possibility of any such reversal of the inhibition with kinetin was then tested. The values of hypocotyl length obtained for kinetin concentrations of 1, 2.5, 5.0, and 10.0 ppm, when given in combination with indole-3-butyric acid at a concentration of 100 ppm, averaged about 5 mm in all the cases on the fourth day, exactly paralleling the figure obtained for indole-3-butyric acid alone. The hypocotyl of the untreated control seedling measured 20.4 mm. On the eighth day the values obtained were: control, 32.2 mm; 100 ppm of indole-3-butyric acid, 21.2 mm; indole-3-butyric acid plus kinetin, 18.6, 19.3, 21.7, and 24.0 mm, respectively, at kinetin concentrations of 1, 2.5, 5.0, and 10.0 ppm. The concentrations of kinetin used in these experiments did not reverse the inhibition of the hypocotyl produced by indole-3-butyric acid.

From these results it can be concluded that high auxin and probably very low gibberellic acid concentration

in the germinating seeds would result in the hypogeal type of seedling growth, while low auxin and relatively high gibberellic acid concentration would result in the epigeal type of seedling growth. Indeed gibberellic acid is being considered as one of the naturally occurring growth regulators (*7*) since it has been extracted from numerous plants and from various types of plant tissues (*8*).

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8. We wish to express our grateful thanks to Dr. Kurt Leben of Eli Lilly and Co. for his generous gift of gibberellic acid, to Prof. R. N. Tandon for providing the laboratory facilities, to Dr. S. Ranjan for encouragement and advice, and to Sri R. K. Srivastava and Sri R. M. Pandey for their assistance.

19 December 1960

Giant Desiccation Fissures on the Black Rock and Smoke Creek Deserts, Nevada

Abstract. Open fissures, from 100 to several hundred feet apart, that have produced polygonal patterns on the Black Rock Desert, Nevada, are believed to be giant desiccation cracks resulting from a secular trend toward aridity in the last few decades. Similar features on the Smoke Creek Desert probably have the same origin.

A system of open fissures that divides a part of the playa of the Black Rock Desert into large polygonal blocks was investigated in June 1960 and again October 1960 (*1*). The fissured area was photographed from the air in October 1960 (Fig. 1), when other extensive fissured areas on both the Black Rock and nearby Smoke Creek Deserts were observed.

The system of fissures on the Black Rock Desert that was studied on the ground commences about 20 miles north of Gerlach on the desert road between Gerlach and Summit Lake and extends northward about 5 miles along the northwestern margin of the playa. The system is 1 to 2 miles wide. The fissures range from less than an inch to about 2 feet in width; in general, the narrower fissures are open to the greatest depths (Fig. 2). The fissures appear to be vertical, and some are open to depths in excess of 4 feet. Minor irregularities in the fissure walls prohibit visual estimation of the depth of many of the narrow fissures. The fissures intersect to form an orthogonal network dividing the playa into blocks with edges from 100 to 250 feet long. The widest and oldest fissures, which are generally shallow because of slumpage of material into the opening, form a master network several times as large as the individual rectangular blocks which appear to have developed by progressive subdivision of the larger blocks.

The fissures on the Black Rock Desert are generally confined to the periphery of the playa, and the fissured areas are generally elongated parallel to the edge of the playa. In some fissured areas there is a preferred orientation of master fissures approximately parallel to the edge of the playa (see Fig. 1*A*), but in other areas no preferred orientation was noted.

The fissures are believed to be very recent; some fissures seem to be extending into unfissured ground at the present time (Fig. 1*B*). Faint drainage features in the fissured areas can be identified on 1:20,000-scale aerial photographs of the area northeast of Gerlach taken for the Soil Conservation Service from 10:00 to 10:20 A.M., 21 July 1954, and at 11:06 A.M. on 9 September 1954; however, fissures cannot be identified on these photographs. Although narrow fissures might not have produced wide enough shadows to be resolved on the 1954 photographs, the present fissures were clearly visible from the air between 9:30 and 10:00 A.M., 20 October 1960 (Fig. 1) and could be seen for distances of several

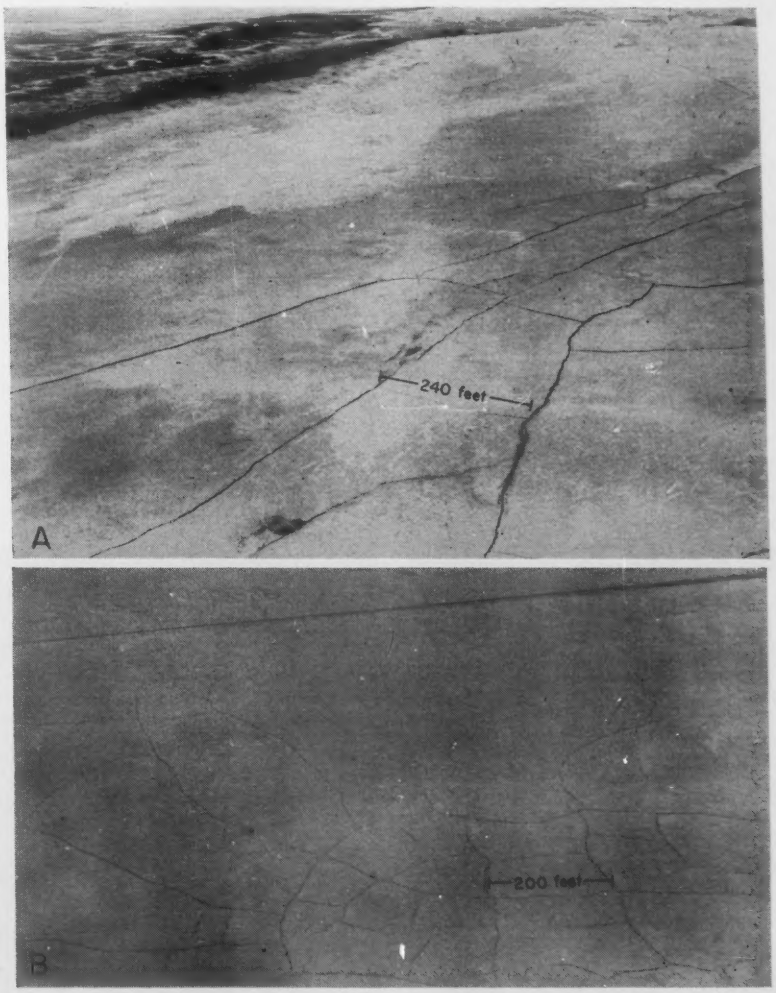

Fig. 1. Oblique aerial photographs of desiccation fissures on the Black Rock Desert, Nevada. Scale is approximate. (*A*) Master fissures approximately parallel to periphery of playa. (*B*) Master fissures extending from polygonal ground into unfissured ground.

miles. One of us (R.W.) traveled the desert road between Gerlach and Summit Lake in the spring of 1957 and did not observe fissures in the 5-mile long area which is now strongly fissured; an alternate road now bypasses this fissured area.

Most of the fissures on the playa of the Smoke Creek Desert, although studied only from the air, appear to be older than those on the Black Rock Desert. The polygonal ground is more widespread on the Smoke Creek Desert, but open fissures were observed at only a few places. The older fissures appear to have been filled either by slumpage, flooding, or wind-blown sand. Lines of vegetation mark the polygonal blocks in one area at the north end of the Smoke Creek Desert. The polygonal ground at this locality looks much like that of the playa of the Animas Valley in New Mexico which was first described by Lang (*2*) and later illustrated by Black (*3*) and Knechtel (*4*).

The large preponderance of orthogonal intersections and the evidence of progressive subdivision, both features of common mud cracks, suggest that the fissures are developing slowly under a progressively increasing stress. The large distance between the fissures indicates that the fissures and the stress producing them extend to considerable depths (*5*). We believe that they are produced by a gradual reduction in volume caused by progressive desiccation of the playa. This is probably the result of a long-term decrease in the supply of surface and ground water from the extensive drainage systems which flow into the Black Rock and Smoke Creek deserts. Rainfall and stream runoff data presented by Antevs (*6*) for the Great Basin indicate that a general period of dry climate commenced between 1910 and 1920, and recent Weather Bureau records show no important reversal in this dry trend.

It is likely that large desiccation fissures will continue to develop on these and other playa lakes of the arid west unless there is a change toward a moister climate (*7*).

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Fig. 2. Open fissure on Black Rock Desert.

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12 December 1960

Reactivation of Rabies Virus Infection with Adrenocorticotropic Hormones

Abstract. A guinea pig inoculated intramuscularly with rabies street virus survived for 5 months, but developed paralysis in the inoculated limb and died of rabies after treatment with adrenocorticotropic hormone.

On 30 November 1959, a group of 34 guinea pigs, being used for a rabies vaccine potency test, was challenged with 0.1 ml of a 1×10^{-2} dilution of rabies street virus (salivary gland) given intramuscularly in the right thigh muscle. Twelve of these animals had not been immunized previously with rabies vaccine; they served as controls. The challenge virus was obtained from the submaxillary glands of a spotted skunk, *Spilogale putorius*. The LD_{50} was 1×10^{-4} in adult mice and $1 \times 10^{-5.4}$ in infant mice when inoculated intracerebrally (0.015 ml). This virus has not been adapted to brain tissue by intracerebral passage; it was obtained from a naturally infected spotted skunk and subpassed by intramuscular inoculation in spotted skunks (*1*).

One control guinea pig died 23 days after inoculation, and brain material from this animal proved to be negative for rabies virus. Five of the remaining animals developed rabies and died after incubation periods of 37, 37, 40, 47, and 56 days, respectively. The cause of death was proved in each instance to be rabies by subpassage of brain material into mice and by demonstration of Negri bodies in the brain tissue of the infected mice. One other guinea pig exhibited signs of central nervous system stimulation, such as hyperexcitability and muscular hypertonicity, beginning 38 days after inoculation, but recovered.

Twenty weeks after inoculation with rabies virus the six remaining control guinea pigs appeared to be healthy. Blood samples were collected from each of these animals, and the serum was tested, individually, for evidence of neutralizing antibodies against rabies virus. Some degree of protection in a neutralization test in mice was demonstrated by three of the guinea pigs, Nos. 3, 4, and 6. Guinea pigs Nos. 1, 2, and 5 presented no demonstrable neutralizing antibodies to rabies virus.

All of the six control animals were given a course of adrenocorticotropic hormone (H. P. Acthar Gel, Armour and Co., 40 units per cubic centimeter) to determine if this procedure would reactivate rabies virus which might be residing in the host's tissues. Beginning on 20 April 1960 each received 0.25 ml (10 units) of the hormone subcutaneously in the abdominal region at 48-hour intervals.

After three injections of this drug and 7 days after the start of treatment, one guinea pig (No. 2) exhibited weakness in the right hind leg. This was the same limb used for the original introduction of rabies virus. Injections of adrenocorticotropic hormone were continued, and paralysis, of an ascending type, progressed. By the 9th day after the hormone treatment was started, complete paralysis of both hind legs was present. This animal died on 2 May 1960, 154 days after inoculation with rabies virus and 13 days after initiation of the hormone injections.

Portions of the brain, salivary glands, and spinal cord from this animal were excised and prepared for mouse passage. Each tissue was tested in separate groups of eight adult mice. Rabies virus was isolated from the brain, but not the spinal cord or salivary glands. The minimum incubation period in mice was 15 days. Brain smears from inoculated mice were Negri and fluorescent rabies antibody positive.

The remaining five control guinea pigs developed no apparent illness and were killed in the middle of May.

The observation presented here suggests a method whereby rabies virus may be reactivated in the tissues of a host by adrenocorticotropic hormone. Of interest is the fact that the animal that developed rabies after treatment with the hormone had no demonstrable virus-neutralizing antibody in the blood, as determined by the mouse neutralization test.

Other evidence showing that a latent virus infection can be activated by chemical means, in this case adrenalin, has been presented recently by Schmidt

and Rasmussen (*2*). Rabbits, partially immunized against and then challenged with herpes simplex virus, were maintained in an apparently healthy state for periods of 24 to 160 days and then placed upon a course of adrenalin injections: a fatal herpetic encephalitis developed within 2 weeks in six of ten rabbits so treated (*3*).

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3 January 1961

An Advancing Glacier in Canada

Abstract. The Commander Glacier, in the Purcell Range of interior British Columbia, advanced 810 ± 50 feet in the 6 years 1954–1960. The advance may be a response to a general cooling trend previously noted elsewhere in the Pacific Northwest.

The glaciers of the Canadian Cordillera have, at least until very recently, been following the world-wide pattern of very rapid shrinkage. The best recent evidence comes from a detailed study of eleven glaciers in the Canadian Rocky Mountains in 1953 (*1*, *2*). All had receded markedly between 1910 and 1950 and were continuing to retreat. In contrast, the Commander Glacier in British Columbia made a significant advance between 1954 and 1960. So far as is known this is the first glacier in interior Canada for which an advance has been noted.

The Commander Glacier lies west of the Canadian Rocky Mountains in the central Purcell Range of British Columbia, 100 miles north of the United States border. A brief glaciological study of this glacier was carried out by one of us in August 1954 (*3*), during the Harvard Mountaineering Club Purcell Range Expedition. The glacier is now primarily a cirque glacier, which occupies a northward-facing valley protected on the south and east by Mount Maye, Mount Commander, Mount Cleaver, and the Guardsmen, all peaks of 10,000 to 11,000 feet elevation. Its greatest length is 2½ miles, and the total area covered by ice is about 4 square miles. Tree-ring dating indicates that the glacier reached its maximum recent extent at about 1820–50, when it extended well into the valley beyond its present cirque basin. The total recession from the 1820–50 terminal moraine to the ice front in 1954 was 6180 ± 100 feet. Most of this recession took place between 1915 and 1947, since photographs taken in 1915 show that the glacier extended nearly to its terminal moraine. The glacier was photographed from the air in 1947 and again in 1953. Little net change in the area covered by ice took place between 1947 and 1954, but in 1954 the ice front was thickened and was quite active.

In August 1960 we remeasured the glacier by using fixed points established in the 1954 survey. The glacier has advanced 810 ± 50 feet since 1954, or an average of about 130 feet per year. Advance has taken place generally along the entire ice front, but is especially pronounced on the west, near the true left (west) lateral moraine. Most of the area underlying the recent advance now appears to be buried beneath at least 100 feet of ice. Blocks of ice were still tumbling from the front of the glacier in 1960, but the activity seemed less pronounced than it was in 1954.

Glaciers have been generally advancing throughout the Cascade and Olympic mountains of Washington state since 1950 (*4*), although advance may have slowed or ceased since 1958. Increased thickness of glaciers, indicating renewed alimentation, has been noted in the Sierra Nevada in California, in the Wind River Range in Wyoming, and in Glacier National Park in Montana (*5*). Glacier rejuvenation in Washington has been associated with a recent trend toward a cooler and wetter climate in that state (*4*, *6*). This trend is also apparent in Canada. Meteorological data from western Canada show increasing temperature and decreasing precipitation from 1910 to the early 1940's, but a reversal of these trends since about 1945 (*1*, *7*).

The advance of the Commander Glacier probably reflects this climatic change. Although the Commander Glacier is for the present a unique case, other glaciers in the interior ranges of British Columbia seem to show signs of incipient advance. An example is the Hermit Glacier in the Selkirk Range, which has become greatly thickened at the snout since 1950 and appeared to be advancing in 1959 (*8*).

The fragmentary data so far available suggest that glacial advances may be manifested first in interior British Columbia, and only later, if at all, in the more easily accessible glaciers of the Canadian Rockies. However, observations of glaciers throughout the Canadian Cordillera during the next few years should be of special significance.

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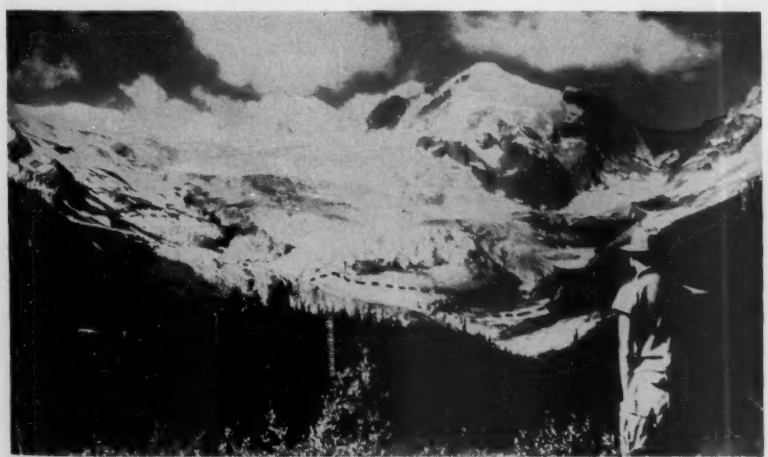

Fig. 1. Commander Glacier in 1954. Dashed line shows approximate position of ice front in 1960.

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20 February 1961

Zinc-65 in Reactor Workers

Abstract. Zinc-65, hitherto found in cyclotron workers and in other specialized populations, has now been detected in a group of reactor workers. While the highest levels detected are less than 0.2 percent of the maximum permissible concentration, the movement of this neutron-induced radionuclide is of interest, and the baseline information is important for future studies.

To date, body burdens of zinc-65 have been detected in the members of three populations: the Marshallese exposed to nuclear fallout resulting from the 1 March, 1954 detonation (*1–3*); a group of individuals who drank water from the Columbia River below the Hanford Atomic Works, or who ate food grown in fields irrigated by this same water (*4*); and particular groups of cyclotron workers (*5, 6*). The present study reports a fourth population with detectable levels of Zn^{65}, a group of specialized reactor workers.

Whole-body gamma counts of seven Marshallese inhabitants, performed at Argonne National Laboratory in 1957, revealed for the first time the presence of Zn^{65} in human beings (*1*). In 1958 and 1959, after the exposed Marshallese had returned to their island, body burdens of gamma emitters of 200 people were measured with a portable whole-body counter (*2, 3*). The mean level of Zn^{65} in male, adult Marshallese in 1959 was 9.4 mμc/kg of body weight, while the mean value of Cs^{137} was 11 mμc/kg, or about 100 times that of an inhabitant of the United States (*3*). The Zn^{65} in the Marshallese derives from local seafood which is consumed (*7*). It was found in 1955 that fish and various mollusks have a marked ability to concentrate this element, as well as other radionuclides (*7*). Zinc-65, a neutron-activated product, was formed as a result of the action of slow neutrons released by nuclear fission on materials associated with weapon testing.

More recently, widespread distribution of Zn^{65} resulting from stratospheric fallout has been detected in a wide variety of foods in this country, although at levels lower than those observed in either the Marshall Islands or the Hanford area. Zinc-65 levels of 178 μμc/kg were detected in Chesapeake Bay oysters and levels of 40 μμc/kg in clams from the east coast (*8*). Zinc-65 at levels of from 30 to 50 μμc/kg has been detected in muscle and liver of Nevada cattle, and in commercial hamburger, beef liver, and milk from the Southwest (*9*). It might therefore be reasonably expected that a Zn^{65} body burden would be detectable in the general population.

Zinc-65 was recently detected in certain cyclotron workers (*5*). This radioactive zinc was produced by neutron radiation of construction material by the reaction $Cu^{65}(d,2n)Zn^{65}$. Similarly, body burdens of Zn^{65} were reported in two cyclotron workers at Massachusetts Institute of Technology (*6*). Van Dilla (*5*) predicted that Zn^{65} would also be found in reactor workers. A study of the gamma spectra of reactor workers, then underway at Brookhaven National Laboratory, already confirmed this prediction.

The gamma spectra of 128 male Brookhaven personnel were obtained in the Brookhaven whole-body gamma spectrometer (*10*). The counter is built around an 8 by 4 in. NaI (T1) crystal detector mounted in a room with 6-in. steel walls. The apparatus utilizes a 100-channel pulse-height analyzer.

Table 1. Primary gamma emitters in reactor workers and other laboratory personnel. Standard deviation $=[\Sigma(x^2)/N]^{\frac{1}{2}}$.

Group	Subject (No.)	K (g/kg body wt)	Zn^{65} (μμc/kg body wt)	Cs^{137} (μμc/g K)
		Reactor personnel		
A	5	2.04 ±0.28	1136 ±60.3	65.5 ±22.8
B	21	2.15 ±0.28	64.6 ±34.4	71.1 ±19.2
C	29	1.89 ±0.23	15.7 ±15.2	56.3 ±15.8
		Nonreactor laboratory personnel		
D	73	1.84 ±0.25	9.31 ±9.24	59.2 ±16.2

The subjects were showered, dressed in hospital clothes, and placed on a cot in a standardized position under the detector and counted for 30 minutes. The precision of the counter (standard deviation/calibration factor) for a 30-minute count was 12.9 μμc/kg of body weight for Zn^{65}, 3 μμc/g of potassium for Cs^{137}, and 4 g for potassium. Both Cs^{137} and K^{40} can be measured to a precision of 5 percent or greater in a normal 70-kg man with a 30-minute counting time.

Typical gamma spectra from two subjects selected from groups with the highest and lowest Zn^{65} body burdens are shown in Fig. 1. The radionuclide abundances were obtained from the pulse-height data for the discrete energies of the gamma rays Cs^{137}, Zn^{65}, and K^{40}. Corrections were made for the background activity and for the Compton contribution of each radionuclide to the photopeaks of the others. Absolute levels of these three radionuclides were obtained by comparison with the spectra of standardized solutions (KCl to provide K^{40}) placed in a plastic phantom of a standard man (REMAB, Alderson). In addition, 1 μc of each isotope, Zn^{65}, Cs^{137}, and K^{42} (substituting for K^{40}), was administered as the chloride to two patients to check their respective spectra with those obtained from the plastic phantom.

Personnel employed in the Brookhaven Research Reactor were arbitrarily subdivided into three groups on the basis of the degree of their potential exposure to radioactive materials. Group A consisted of workers who handle isotopes which are moved in and out of the pile by pneumatic tubes for irradiation. The mean Zn^{65} level of this group was considerably higher than any other group (Table 1). The Zn^{65} in these workers presumably derives primarily from the reaction, Zn^{64} (n,γ) Zn^{65}. Zinc is present in external brass

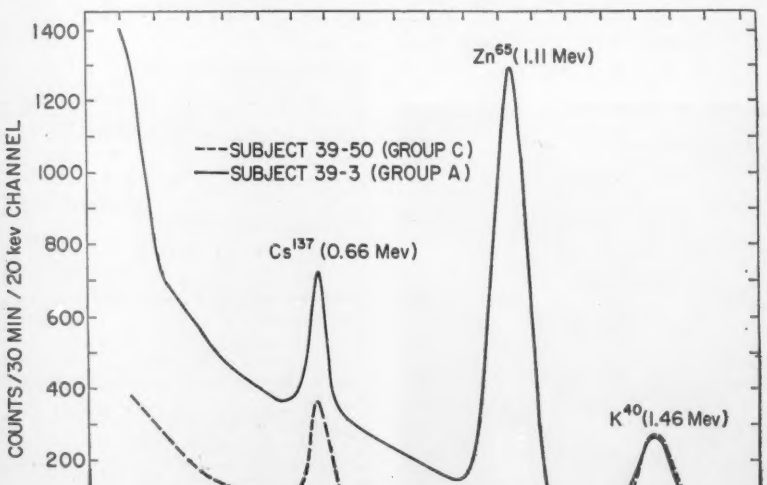

Fig. 1. Gamma-ray spectra of two reactor workers measured in whole-body spectrometer.

fittings of the pneumatic tube system of the reactor. Probably the zinc is carried into the reactor, irradiated, and, on removal, inhaled by the reactor workers.

Group B was composed primarily of pile operators and other personnel such as health physicists who work on or near the reactor. These people were selected on the basis of having higher than normal levels of activity in their urine. Over 66 percent of the individuals in this group had Zn^{65} body burdens in the range of 40 to 120 $\mu\mu$c/kg of body weight.

Group C was composed of personnel working in the reactor building but presumably having minimal occupational exposure and no detectable level of activity in the urine above background.

Group D was composed of individuals who represent part of a continuing survey of Brookhaven personnel and serves here as a control group against which the spectral data of the reactor workers can be compared. The Zn^{65} levels in groups C and D are below the limit of detection of the whole-body counting apparatus for a 30-minute count.

In addition to the Zn^{65} activity, Cs^{137} and K^{40} were measured in all subjects. The K^{40} content averaged 1.84 g/kg of body weight. This figure agrees well with K^{40} measurements in other similar studies (*11–13*).

The level of Cs^{137} has had a worldwide increase since 1955 and appears to have reached a maximum value in 1959 in the world population (*11–14*). In the present study, the average was 59 $\mu\mu$c/g of potassium in nonreactor personnel (June 1960) as compared to 52 $\mu\mu$c/g of potassium at the same time in England (*14*). The Cs^{137} body burden has its origin in world-wide fallout and is associated with ingestion of fallout-contaminated food, particularly milk (*11, 14*). A correlation was found in the present study between the amount of milk consumed by an individual and his Cs^{137}/K ratio.

The interest in Zn^{65} is not based on the radiation hazard that may result from its internal deposition, as even the highest levels detected in the reactor workers of group A were less than 0.1 μc, which is far below the maximum permissible concentration of 60 μc stated by The International Commission on Radiation Protection. Rather, the course of this isotope is interesting because it reveals how a radionuclide—in this case not a fission product, but an induced activity—moves through the food chain or through the atmosphere ultimately to deposit in man. It is of importance to establish baselines for unexposed populations for Zn^{65} and other radionuclides to provide data against which possible increases in body burdens may be measured. Fortunately, the current availability of whole-body gamma spectrometers makes feasible such general population studies. It is, of course, equally important in future studies to keep occupationally exposed personnel in nuclear energy establishments under close surveillance (*15*).

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19 December 1960

National Academy of Sciences

Abstracts of Papers Presented at the Annual Meeting, 24–26 April 1961, Washington, D.C.

Dielectric Constants and Molecular Interactions in Carbon Dioxide and Ethylene

Measurements at pressures from 1 to 100 atm have been made with sufficient precision to determine density dependent effects attributable to pair interactions of molecules in the two gases. For CO_2, the data show larger dielectric constant increases at 50°C than at 75°C and are satisfactorily explained by the induced polarization effect of a molecular quadrupole moment of about 5×10^{-26} esu cm^2, a figure in reasonably good agreement with other estimates. For ethylene, relatively large increases are also observed, but they increase with temperature in the range 25° to 75°C. This behavior is contrary to theories of quadrupole-induced dipole interactions, even when generalized to molecules lacking axial symmetry. These theories, however, either neglect quadrupole coupling energy or assume that it is small compared with kT. Calculations indicating that the effects of this energy are significant will be discussed, as will experiments which should further clarify the significant interactions between nonpolar molecules.

ROBERT H. COLE
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Linear Stark Effect in Magnetic Resonance Spectra

If a nucleus or paramagnetic ion with spin greater than one-half occupies a site in a crystal lattice without inversion symmetry, an externally applied electric field will cause, in general, a change in the quadrupole coupling constant or crystalline field splitting proportional to E.

The effect of deformation of the unit cell is additive to the explicit Stark effect at constant strain. The phenomenological description can be given in terms of tensors of third and fourth rank, which are similar to those used by Pockels for the description of the electro-optic and elasto-optic effects in crystals.

An individual ion or nucleus may occupy a site without inversion symmetry, even though the crystal as a whole has such symmetry and is not piezoelectric.

The magnitude of the linear Stark effect in ionic crystals can be readily estimated on the basis of the point charge model. The change in crystal field gradients due to relative displacement of the ions in an applied electric field should, for example, be observable for the nuclear quadrupole resonance of Cl^{35} in $KClO_3$ and for the electron spin resonance of Cr^{+++} ion sit-

uated near a vacancy in the MgO lattice. Kushida (private communication) has recently observed the effect, linear in E, on the quadrupole resonance of Br in $NaBrO_3$, although not at constant strain.

Effective g-tensors and higher order parameters in spin hamiltonians will of course also change linearly with E, if the ionic site lacks inversion symmetry. Such effects might be observable for rare earth ions in double nitrates.

If the electric field is varying at a frequency corresponding to resonance between a pair of spin levels, transitions may be induced at a rate proportional to E^2. This absorption can formally be described by an effective dielectric susceptibility, but this has, of course, nothing to do with the existence of an electric dipole moment. The strength of the electrically induced transitions, which may have $|\Delta m| > 1$, will be compared with the usual magnetic dipole transitions.

N. BLOEMBERGEN
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Spark Chamber—Useful Detector for High-Energy Particles and Cosmic Rays

The spark chamber has recently come to the fore as a visual detector of high-energy particles. In the form developed by S. Fukui and S. Miyamoto [*Nuovo Cimento* **9**, 113 (1959)] the spark chamber consists of a multiplicity of plates in one atmosphere of neon gas, connected in such a way that the passage of a high-energy particle through the chamber triggers a circuit which puts a high voltage between alternate plates of the chamber. The voltage is high enough to produce sparks between the plates which occur preferentially along the path of the particle because of the ions which it produced there. The result is a series of bright sparks along the track of the particle which is easy to see visually. The importance of these detectors has been emphasized by J. W. Cronin and G. Renninger, and by Beall, Cork, Murphy, and Wenzel (Proc. Intern. Conf. on Instrumentation for High-Energy Physics, Berkeley, Calif., 12–14 September 1960), who have used these chambers successfully in a number of experiments with high-energy machines. A multi-plate spark chamber will be demonstrated which displays very nicely the μ-mesons of the cosmic rays. Some of the properties and applications of such a spark chamber will be discussed.

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Search for Microbial Causes of Common Illnesses

During a 3-year period, we studied 479 normal babies who lived for a week or longer under somewhat crowded conditions in a District of Columbia welfare institution. The population averaged 54 per week, the children averaged four admissions per week, and each child averaged 18 weeks of residence. Clinical observations included medical surveillance with rectal temperatures on each child every day. Laboratory observations included routine blood specimens and a search for microbial agents in throat and anal specimens collected from each child at least once a week.

Of 2823 febrile episodes observed, 1771 were classified as acute undifferentiated illnesses. Of the 4234 infections with 57 virus and 54 bacterial serotypes observed, 1502 virus and 703 bacterial infections were found in routine tests considered reasonably adequate for the specific agents. The study was designed so that illnesses and infections would be identified independently of each other by objective criteria. The frequency of definite undifferentiated illness during the week when a specific microbe was first isolated from children in routine specimens was compared (i) with the frequency of such illnesses in the same children during the two prior and two subsequent weeks, and (ii) with the frequency of illnesses in other children living in the institution during the weeks when new infections were occurring. At least eight virus and four or more bacterial serotypes were found significantly associated with the occurrence of acute undifferentiated illness. Serologic studies are now underway which make possible more precise analyses of such associations with more definitive end-points. To date, such analyses have not altered conclusions as to which agents were associated with illness.

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Encouraging Results in Long-range Weather Prediction

A comparison of the monthly precipitation at 32 cities, in 1959 and 1960, with a forecast from November 1956 is presented.

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Guided Propagation of Radio Waves in the Magnetosphere

The magnetosphere is the portion of the earth's outer atmosphere where collisions are so infrequent that the distribution of ionization-density is strongly influenced by the earth's magnetic field. In consequence, ionization is filamented in tubes along the earth's magnetic field, and guidance of electromagnetic waves around the tubes is possible. A theory of this guidance has been developed for the oversimplified situation in which there is a discontinuity of ionization-density across a surface formed by rotating a line of flux of the earth's magnetic field around the axis of the field. The theory is similar to that for a whispering gallery in acoustics.

The theory helps to explain the phenomenon of "whistlers." This is a phenomenon in which the electromagnetic pulse from a lightning flash is guided from one hemisphere to the other around the lines of flux of the earth's magnetic field and is thereby distorted into a descending whistle that may be detected at audio frequencies. Extension of the theory up to a radio frequency of 10 Mcy/sec suggests that propagation between the hemispheres around the lines of flux may be possible at frequencies above the penetration frequency of the ionosphere. Extension of the theory down to frequencies of the order of 1 cy/sec shows that hydromagnetic waves may also be guided around the lines of flux.

HENRY G. BOOKER
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Two Metabolically Active Peptides from Pituitary Extract

As reported here in 1953, corticotropin was the most active pituitary principle evoking mobilization of fat in rats and mice. In the rabbit, however, Rudman has found that extracts depleted of recognized anterior pituitary hormones mobilize depot fat and induce lipemia. Material of this type has now been found in the acetic acid extract of porcine anterior lobes remaining in the manufacture of corticotropin with oxycellulose [*J. Am. Chem. Soc.* **73**, 2969 (1951)]. Neutralization of the 2.5 percent solution precipitated 80 percent of the solids. The active soluble fraction upon electrophoresis on starch gel at *p*H 8 showed that the most active material was represented by two rapidly moving anionic bands; the gel pattern guided purification. An impure mixture of the two peptides was recovered by adsorption on a minimal amount of Dowex 1-X2 acetate resin. They were retained by columns of this resin at *p*H 3.5 or above and eluted by gradients toward 0.1*N* acetic acid or toward stronger buffers of *p*H 3.5 to 4.0; peptide I, the slower moving on starch gel, emerged first followed by peptide II mixed with I. Both were retarded somewhat by Sephadex G-50, but peptide I was retarded more. Peptide II was more easily precipitated with trichloroacetic acid and could thus be obtained free of peptide I. In 1 ml of medium, .02 μg of the two peptides enhanced release of free fatty acid from leporine adipose tissue in vitro; 10 μg given intravenously trebled fatty acid in serum in 10 minutes; 1.5 mg induced gross lipemia in 12 hours, while larger doses were often lethal before lipemia developed.

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Electron Microscopy of Deoxyribonucleic Acid Macromolecules in Solution

Electron microscope observations have been made of deoxyribonucleic acid (DNA) molecules under conditions approaching the native hydrated state by sandwiching a thin layer of DNA solu-

tion between impermeable ultrathin films in microchambers of special design and by using microbeam illumination of very low intensity [H. Fernández-Morán, *J. Appl. Phys.* **31**, 1840 (1960)]. In T2 bacteriophage DNA preparations thin fibrils about 30 to 40 μ long were seen formed by unit filaments of 20 A diameter in ordered lateral aggregation with indications of axial discontinuities of approximately 30 A. Oriented DNA fibers have also been mounted in vacuum-tight microchambers at controlled relative humidity in a form suitable for electron-diffraction studies. Irradiation with electron beams of higher intensity produces characteristic fragmentation of the filaments in wet DNA preparations, differing from the relatively stable appearance of the strands in dried specimens. With improved pointed filament sources and collimation devices, electron microbeam irradiation can be restricted to accurately defined regions of 100 to 1000 A along the fibrils. The described techniques provide the means for direct observation of radiation damage in selected macromolecular regions of hydrated biological systems under the electron microscope. This work was supported by a U.S. Atomic Energy Commission contract and by a grant from the National Institutes of Health.

HUMBERTO FERNANDEZ-MORAN
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Massachusetts Institute of Technology

Thermodynamic Potentials of Symmetrical Electrolytes

The Poisson-Boltzmann equation proposed by Debye and Hückel for the potential of a reference ion in an electrolytic solution has been integrated in two steps: in the first, the positive exponential function is explicitly retained, giving the potential accurately in the vicinity of the reference ion. By applying the conditions of continuity of potential and field at the distance $r = e^2/2\ D\ k\ T = \beta/2$ (the Bjerrum radius), this potential goes over smoothly into the Debye-Hückel potential, valid for large distances from the reference ion. The resulting limiting law for the thermodynamic potential for the case of point charges is of course unchanged, but for the sphere-in-continuum model, we find $-\ln f = \tau/(1+\tau)$, where f is activity coefficient and $\tau = \beta\kappa/2$ is a dimensionless rational independent variable determined by concentration, valence and the $D\ T$ product. The ion size a appears only in higher terms, the first of which has the functional form previously derived by the *ad hoc* hypothesis of ion association. The deviations between the above limiting expression for $\ln f$ and the experimental data are opposite in sign to those obtained by retaining further terms of the Poisson-Boltzmann equation; it is suggested that they can only be accounted for by extension of functions characteristic of the fused salt into and through the regions of high and moderate concentrations.

RAYMOND M. FUOSS, LARS ONSAGER
Yale University

Prophylactic Adrenalectomy for Advanced Breast Cancer

The condition of patients with carcinoma of the breast and wide-spread metastases, who have secured palliation from removal of the ovaries and adrenal glands, deteriorates quite rapidly when growth in the dormant metastases is resumed. Apparently, mutant malignant cells have appeared that can grow rapidly in the absence of the hormones of these glands. It would seem that the chance for such mutants to develop would be much greater when large masses of cancer cells are actively dividing than when the metastases are of small size. Twenty-four consecutive patients with recurrent cancer of the breast were treated by bilateral oophorectomy and adrenalectomy. Fourteen, or 58 percent, showed marked subjective improvement and survived for an average of 44 months. Seven patients are still living, an average of 60 months since adrenalectomy. The results secured in this series of patients are better than in some series reported by others. This may be in part because of the fact that adrenalectomy was carried out in a number of patients with minimal metastatic involvement. In one patient removal of the ovaries and adrenal glands was performed shortly after radical mastectomy. The specimen revealed a highly invasive tumor with involvement of most of the axillary glands and permeation of cancer cells into the lymphatics, blood vessels, and subcutaneous tissue. Distant metastases were not demonstrated, but were believed to be present. This patient has remained well without evidence of recurrence and has continued her usual activities for nearly 9 years. It is suggested that oophorectomy and adrenalectomy be employed as soon as metastatic lesions from breast carcinoma are diagnosed or are believed to be almost certainly present.

LESTER R. DRAGSTEDT
University of Florida

Biosynthetic Activation Accompanying the Transformation of Normal to Tumor Cell in Plants

The transition from normal to tumor cell must involve a major permanent switch in synthetic capabilities, going from a conservative, precisely regulated metabolism to one involving an increased synthesis of the nucleic acids, mitotic proteins, and other substances required specifically for cell growth and division. An understanding of the tumor problem would appear, therefore, to be concerned with a characterization of the cellular mechanism(s) responsible for this major permanent switch in synthetic metabolism. In studying this problem, a nonself-limiting tumor disease of plants known as crown gall was used as the experimental model. In this system the transformation of normal to tumor cell involves a gradual and progressive activation of a series of quite distinct but well-defined biosynthetic systems that represent the entire area of metabolism concerned with cell growth and division. The products of these systems include two intracellular hormones which act synergistically to promote growth and cell division, glutamine, meso inositol, as well as a purine and pyrimidine. The mechanism by which the entire area of metabolism concerned with growth and cell division becomes progressively and permanently activated during the transformation process has been studied further. Evidence has been obtained to indicate that certain of the biosynthetic systems shown to be unblocked in the plant tumor cell are ion-activated systems. This, in turn, suggests that changes in membrane permeability or ion-transport mechanisms accompany the cellular alteration, and, as a result of such changes, essential ions penetrate to the proper locus in a tumor cell where they activate certain essential biosynthetic systems.

ARMIN C. BRAUN
Rockefeller Institute

Electromagnetic Structure of the Proton and Neutron

New data have recently been obtained on the electromagnetic form factors of the neutron. These data are obtained by studying the inelastic electron-deuteron scattering at high energies. By using as normalization data the absolute cross sections known for the proton it is possible to find the absolute peak cross sections for the deuteron by experimental comparison of deuteron peaks and proton peaks. The modified Jankus theory is then employed to find the neutron form factors. The neutron form factors are considered together with the proton form factors as a body of data from which the structure of the proton and neutron can be deduced. We have developed four isotopic form factors which are taken as building blocks for proton and neutron form factors. The isotopic form factors are shown to be consistent with present experimental cross sections of the proton and neutron, including their rms radii. This formulation predicts that the neutron has a positively charged outer cloud. The neutron and proton are each composed of two Yukawa-type clouds having different ranges. Each particle also has a point-like core. Details of this attempted explanation will be given.

R. HOFSTADTER
C. DE VRIES*
Stanford University
ROBERT HERMAN
General Motors Corporation
*On leave of absence from the Institute of Nuclear Research, Amsterdam.

Automatic Recording Techniques for the Chromatography of Peptides and Proteins

Before a fundamental understanding of the reactions in which proteins participate in living cells can be attained, we need to know the chemical structures of not one or two but many proteins of different origins and different functions. The

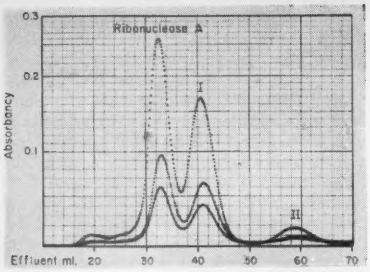

Fig. 1. Recorded chromatographic separation of ribonuclease A from the imidazole carboxymethyl derivatives on a 0.9 by 38 cm column of Amberlite IRC-50.

chemist is concerned with making the methods used for this purpose as expeditious as possible. It is proving feasible to place several of the principal analytical steps in a structural study on a recording basis. The equipment developed for automatic amino acid analysis is also being applied to a number of peptide separations. A tryptic hydrolysate of reduced and carboxymethylated ribonuclease can be effectively fractionated into the majority of its smaller individual components in a 7-hour run on a 15-cm column of Amberlite IR-120. The reproducibility of detail in the resulting effluent curves facilitates careful comparative studies of protein structures. The chromatography of proteins themselves can also be expedited in a number of similar ways, one of which is illustrated in Fig. 1 for the 120-minute separation of ribonuclease from alkylated derivatives.

STANFORD MOORE
ARTHUR M. CRESTFIELD
Rockefeller Institute

Rapid Induction of Mammary Cancers and Their Suppression

A single feeding of certain polynuclear hydrocarbons to healthy female rats of the Sprague-Dawley strain, age 50 days, evokes mammary cancer selectively, invariably, and rapidly. Whereas small mammary cancers are present 14 days after the feeding, the first visible cancer arose 20 days after the single meal. Ten hydrocarbons with this special carcinogenic property have been recognized; of these 7,12-dimethyl-benz(a)anthracene is the most effective, whereas 2-aminofluorene has the simplest structure.

In the carcinogenic process the following factors have been detected: absorption, transport, fit, and damage of selective sort. It is most probable that charge transfer of electrons is involved. Nucleoproteins are certainly a factor.

It is possible to accelerate the development of the breast cancers or to suppress them entirely. Pregnancy, at age 65 days, or the administration of progesterone solo enhances the development of mammary cancer in rats fed a single meal of DMBA at age 50 days. But the administration to their mates (which likewise had been fed the carcinogen at age 50 days) of estradiol-17β and progesterone at age 65 days, although it causes gestational development of the mammary glands, is a highly effective method of suppressing the young cancers. Cancers suppressed in this way never recurred—they were extinguished.

CHARLES HUGGINS
Ben May Laboratory for Cancer Research, University of Chicago

Mutagenic Effect of a 5-r Dose of X-Rays in Drosophila melanogaster

An experiment to examine the mutagenic effect of a dose of x-rays at a level comparable to the 30-year background dose received by human beings has been conducted during the past 2½ years. Minute bristle mutations, dominant mutations which occur at more than 50 loci in the *Drosophila* genome, serve as the basis of the scoring. The total experiment to date consists of a series of 40 repetitions of the experiment, each repetition consisting of identical numbers of control and irradiated cultures. Both parents are irradiated with 5 r, so that the effective dose to the offspring is 10 r, although each irradiated gamete has received only 5 r. Coding is used so that scorers are not aware of the identity of the irradiated cultures. Environmental variables and scoring variables are randomized insofar as possible. From dosage curves at 1000 to 2000 r and from assuming a linear proportionality of mutations to dose, the prediction was made that the increase in mutation rate would be 0.005 percent, in comparison with a spontaneous rate of 0.04 percent. To date, 585,927 individuals have been scored in the controls and 577,515 in the irradiated series, with 283 mutations in the controls and 323 in the treated series. The over-all control rate is 0.048 percent, or slightly above the prediction, and the difference (0.007 percent) is also a little greater than expectation. The difference lies at the 5 to 7.6 percent level of probability due to chance (depending on the criterion for exclusion of clusters). There is also a highly significant reduction in the number of progeny from the irradiated parents, amounting to 1.3 percent. Other visible mutations are also in excess, though not significantly. It may be tentatively concluded that an acute dose of 5 r produces mutations, at a rate linearly proportional to the effects at 1000 r and 2000 r, in the mature gametes of both sexes of *Drosophila*.

H. BENTLEY GLASS
REBECCA K. RITTERHOFF
Johns Hopkins University

Extreme Ultraviolet Light of the Night Sky Measured from Rockets

The Lyman-α glow of the night sky was first observed in 1955 and was then attributed to resonant scattering of solar radiation by neutral hydrogen in interplanetary space. Subsequent theories and spectrographic evidence have pointed to a geocoronal origin of the glow phenomenon, but do not eliminate the possibility of a small contribution from the interplanetary medium.

Helium is present in relatively high concentration in both the sun and interstellar space, whereas it is very scarce in the earth's atmosphere. Also, because of its relatively high ionization potential, a major fraction of helium may be expected to occur in the neutral and singly ionized states, in contrast to the case for hydrogen which must be almost entirely ionized. Recent measurements of the extreme ultraviolet solar spectrum show that the strongest emission lines are He I (584A) and He II (304A), both of which may be resonantly scattered by He I and He II in the interplanetary gas.

A search for a night sky glow in the He I and He II resonance lines was conducted from an Aerobee rocket in November 1960 with negative results. The experiment sets an upper limit of about 3×10^{-4} erg cm^{-2} sec^{-1} ster^{-1} on the intensity of any helium glow. This is less than 10 percent of the intensity of the hydrogen glow. The significance of this result in connection with the density of gas in the interplanetary medium will be discussed.

HERBERT FRIEDMAN
U.S. Naval Research Laboratory

Evolution at a Single Locus in Maize

The ancestral form of maize was probably pod corn, a type in which the kernels are enclosed in glumes as they are in other cereals. The genetic basis of pod corn is a locus on the fourth chromosome at which three alleles, *Tu*, *tu*^{h}, and *tu* are recognized. Six genotypes involving all combinations of these alleles have been compared in isogenic stocks. The genetic changes through this series from *TuTu* to *tutu* are accompanied by the following effects: (i) The tassel becomes less prominent and wholly staminate. (ii) The central spike of the tassel increases in size and the branches decrease in number. (iii) The ear increases in size and weight at the expense of the tassel. (iv) The rachis, the seed-bearing organ containing the system of supply, is enlarged and the glumes, which enclose the grains, are reduced. (v) The grains increase in size and number.

The weight lost in the tassels is accompanied by a gain of approximately fivefold in the ears. The middle position on the stalk of the corn ear apparently has both mechanical and physiological advantages over the terminal position characteristic of other cereals. This may account for the higher maximum yields of corn. In a simulated wild habitat, however, the ancestral form, pod corn, bears all of its seeds in the tassel and has a marked selective advantage over the genotype of cultivated corn. Consequently, evolution at this single locus has rendered the corn plant less able to survive in the wild and much more useful to man.

PAUL C. MANGELSDORF
HELEN P. MANGELSDORF
Harvard University

Charge Fluctuation Forces, Biological Specificity, and Replication

Because of charge fluctuation forces (in particular, London–van der Waals forces) molecules of several varieties, when immersed in a liquid, tend to rearrange themselves so as to bring molecules of identical types together as nearest neighbors. This comes about after Brownian motion has shuffled the molecules and introduced like molecules to each other. How strong is this effect and under what conditions is it significant? These questions are of importance in view of the phenomenon of crystallization and in view of their biological implications.

If two identical protein molecules contact each other, there may result an interlocking of corresponding pairs of identical side chains: sets of large amino acid side chains of the molecule interleaved, somewhat as the two halves of a zipper. This highly specific association may account for the synapsis of homologous chromosomes during meiosis (especially inverted synapsis). It may also account for the species-specific attachment between sperm and egg and for the organ-specific attachment between cell and the organ to which they belong. Primarily, it may be responsible for replica formation in the biosynthesis of proteins and nucleic acids by assembling its constituent filial monomers next to the given chain of parental monomers.

Biological specificity implies a great many mechanisms and different types of forces (as does crystallization). These are often in competition with each other so that in many instances it is steric compatibility, charge, or hydrogen bond complementarity which determine intermolecular attachment. In other cases charge fluctuation forces are the determining factors.

HERBERT JEHLE
George Washington University

Polyribonucleotide Synthetase

An enzyme isolated from the soluble cytoplasmic fraction of spinach leaves catalyzes the incorporation of the label of ATP-C^{14} into ribonucleic acid (RNA). This activity was purified approximately 60-fold. Little, if any, polynucleotide phosphorylase activity was detected by the specific P^{32}-ADP exchange assay for this enzyme.

Maximal incorporation of the radioactivity of ATP is obtained in the presence of all four ribonucleoside 5′-triphosphates, ATP, GTP, UTP, and CTP. Magnesium ions and RNA are essential requirements. However, RNA has to be combined with the protein prior to its addition to the reaction mixture. The addition of RNA, if not preceded by recombination, is ineffective. Deoxyribonucleic acid (DNA) cannot be substituted for RNA and the incorporation of ATP-C^{14} is not affected by the presence of deoxyribonuclease. With the enzyme recombined with tobacco mosaic virus and RNA, incubation for 4 to 12 hours with equimolar amounts of all four nucleoside triphosphates led to synthesis of RNA in 67 to 85 percent excess over the primer.

The above findings suggest that the enzyme is different from polynucleotide phosphorylase and also from recently reported enzymes in liver nuclei and bacteria that catalyze a DNA-dependent incorporation of nucleotides from ribonucleoside triphosphates into RNA.

K. K. REDDI
New York University School of Medicine

Broken Symmetries

A symmetry of one elementary particle interaction may be broken by another interaction. For example, the charge independence of nuclear forces (along with the equality of neutron and proton masses) is violated by electromagnetism. Recently it has been suggested that in some cases symmetries may exist that are badly broken, either by strong interactions or by rest masses. How then can we ever tell that the underlying symmetry is correct and applies to the "bare" masses and coupling constants? It is suggested that certain experiments at high energies and momentum transfers may permit the measurement of ratios of "bare" quantities and provide tests of broken symmetries.

MURRAY GELL-MANN
California Institute of Technology

Ion Distribution Patterns of Stationary State Systems

Upon consideration of a theory of coupled steady-state processes, a branch of the discipline of irreversible thermodynamics, it is possible to derive expressions for the steady-state ion-distribution patterns in the system phase α, transition zone, phase β which we take to be an idealized version of the biological system, internal environment, membrane, external environment. An outline of the theory in terms of the basic concepts employed and the details of an experimental test of the theory when a stationary state of the first order exists in the system will be presented. For example, when the system contains water, NaCl, and KCl, and when water is the only substance flowing through the membrane, the distribution function $(\Delta\mu_{Na} + \Delta\mu_{Cl}) / (\Delta\mu_K + \Delta\mu_{Cl})$ should be approximately equal to 1.2. Furthermore, it is found that when the external environment contains equal concentrations of Na and K ions and the water is flowing from the internal to the external environment, the internal environment contains a concentration of K ion about three times that of the Na ion. This research was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

LESLIE F. NIMS
Brookhaven National Laboratory
ROBERT E. THURBER
Brookhaven National Laboratory and *Adelphi College*

Enzyme Specificity in Activation and Transfer of Amino Acids to Ribonucleoprotein Particles

Two steps in protein biosynthesis are (i) activation and attachment of each amino acid to its specific acceptor RNA (S-RNA) and (ii) amino acid transfer from S-RNA to ribosomal protein. Each activating enzyme (involved in the first step) is specific for one amino acid and its S-RNA. Other enzyme(s) in the cytoplasmic fluid catalyze reaction (ii). This enzyme activity has been partially purified [D. Nathans and F. Lipmann, *Biochim. et Biophys. Acta* **43**, 126 (1960); R. Rendi, unpublished data].

We find that the amino acid–activating enzymes in cytoplasmic supernatants of yeast and rat liver catalyze the activation and transfer of leucine-C^{14} to both yeast and rat liver but not to *Escherichia coli* S-RNA. Reciprocally *E. coli* (and other bacterial) activating enzymes catalyze leucine activation and transfer to *E. coli* but not to yeast or rat liver S-RNA. The transfer enzymes in the cytoplasmic supernatant of yeast and rat liver catalyze transfer of leucine-C^{14} from S-RNA of various origins (yeast, rat liver, *E. coli*) to rat liver but not to *E. coli* ribosomes, and, reciprocally, the *E. coli* enzymes catalyze transfer to *E. coli* but not to rat liver ribosomes. Thus the transfer enzymes from bacterial or animal sources are specific for the corresponding ribosomes but not for the amino acid–S-RNA intermediates. Similar observations have been made independently by Nathans and Lipmann (personal communication). The transfer reaction to *E. coli*, but not to rat liver ribosomes, is inhibited by chloramphenicol or terramycin. These antibiotics appear to inhibit the bacterial ribosomes.

RENZO RENDI, SEVERO OCHOA
New York University School of Medicine

Transport Equations of a Plasma

The transport equations of a plasma, however dilute, are given by

$$\frac{\partial f_1}{\partial t} + v \cdot \nabla f_1 - \frac{e}{m_1}\left(E + \frac{1}{c} v \times B\right) \cdot \nabla_v f_1 = \left(\frac{\partial f_1}{\partial t}\right)_{coll} = \frac{1}{m_1}\frac{c}{n} P_{21} \qquad (1)$$

$$\frac{\partial f_2}{\partial t} + v \cdot \nabla f_2 + \frac{e}{m_2}\left(E + \frac{1}{c} v \times B\right) \cdot \nabla_v f_2 = \left(\frac{\partial f_2}{\partial t}\right)_{coll} = \frac{1}{m_2}\frac{c}{n} P_{12} \qquad (2)$$

where I follow the notation of M. N. Rosenbluth and N. Rostoker [*Phys. Fluids* **2**, 23 (1959)], but supply an equivalent notation for the last terms.

The condition that there are equal and opposite charges per cubic centimeter of the two gases, the electron gas and the ion gas, with $Z = 1$, leads to the equation

$$n_1 \cong n_2 \cong n \qquad (3)$$

The condition that the convective change of momentum of the electron gas per cubic centimeter is equal and opposite

in sign to that of the positive ion gas per cubic centimeter leads to the equation

$$P_{21} + P_{12} = 0 \qquad (4)$$

and not that $P_{12} = 0$ and $P_{21} = 0$.

Assuming that m_1 is negligibly small compared to m_2, and using L. Spitzer's definition of the new terms [*Physics of Fully Ionized Gases* (Interscience, New York, 1956), pp. 20–21], but retaining $v_2 \cdot \nabla v_2$ in dv_2/dt I have Spitzer's two Eqs. 2-11 and 2-12 entirely equivalent to Eqs. 1 and 2. However, I retain $(c/en)P_{12}$, not replacing it by ηj, because I believe Spitzer's Eq. 2-13 is not applicable here.

Assume the term

$$\frac{m_e c^2}{ne^2} \frac{\partial j}{\partial t}$$

is negligible in Eq. 2-12 of Spitzer and taking a two-dimensional symmetrical distribution of plasma within a long circular right cylinder, and assuming that E_θ is negligibly small, I find for the θ component of the force exerted by the relatively moving electrons upon the ions

$$P_{12\theta} = -\frac{ne}{c} v_{2r} B_z$$

This force, which is neglected by most theoreticians, makes the containment time of the enclosed plasma independent of the magnitude of the magnetic field.

The so-called "magnetic bottle" for retaining a hot plasma from a cold wall is but a fantastic dream.

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Evaporation Resistance as a Sensitive Measure of the Purity and Molecular Structure of Monolayers

This report is a continuation of our studies on monolayers [La Mer and Barnes, *Proc. Natl. Acad. Sci. U.S.* **45**, 1274 (1959)].

Before undertaking temperature-coefficient studies, the reproducibility of evaporation-resistance measurements required further examination. Samples purified for laboratory studies and also commercial materials or mixtures for practical application on reservoirs have been examined. A number of the evaporation resistance-surface pressure curves reported in the previous work have been confirmed—in particular those for pure octadecanol, hexadecanol, and stearic acid. The extreme sensitivity of evaporation-resistance measurements to the presence of minute amounts of impurities is illustrated by these results. Such measurements on samples purified by different methods indicate appreciable differences in purity which are not apparent from melting-point determinations. The effects of impurities predominate at low surface pressures, yielding abnormally low values of evaporation resistance accompanied by poor reproducibility. At higher pressures these effects are less significant because of the impurities being squeezed out of the monolayer. Also a higher degree of reproducibility can be obtained for a given specimen. The squeezing out of impurities is time-dependent, which is evidenced by an increase in evaporation resistance when the monolayer is maintained under pressure. The variability observed at lower surface pressures (< 15 dy/cm) is now attributed to uncontrollable differences in the rate at which minute amounts of contaminants or of solvent are squeezed out.

The behavior of the monolayers under pressure as a function of time provides a criterion of the purity and rearrangement of molecular structure. In general, higher purity results in greater stability under compression.

The resistance to evaporation through monolayers of a particular chain length is determined primarily by the nature of the polar head group and its influence on compressibility of the monolayer through packing of the hydrocarbon chains. The region of relative independence of evaporation resistance upon surface pressure observed for compounds with a divided head group in the liquid-condensed phase is attributed to a rearrangement of the polar head groups before the transition to the solid-condensed phase.

VICTOR LA MER, L. A. G. AYLMORE
Columbia University

Classification of Clusters of Galaxies

A classification of clusters of galaxies by means of the forms of the brightest members is outlined. The form types of the individual component galaxies are based on a system that I devised earlier. The principal parameter of this system is a measure of the average stellar constituents of the brighter, inner parts of the individual galaxies.

The classification system for clusters of galaxies is applied to the nearest clusters of Abell's catalogue. The results indicate a remarkable uniformity in the stellar population of the brightest galaxies in different clusters.

W. W. MORGAN
Yerkes Observatory, University of Chicago

Aid to Music Composition with a Random-Probability System

The art of music composition can be learned to some extent by following the work of composers combined with a knowledge of the fundamentals of music. Composition can be stimulated by various experiences and may be aided by research. However, the process which operates in the mind of the composer is not understood. Even without such knowledge, it is possible to develop machines which can aid the composer in his search for melody, which is the essence of most music. The ability to create is a gift. Nevertheless, even great composers have at times turned to mechanical aids for assistance. In this connection, random-probability systems allow the generation of sequences of notes in a series which are not completely random nor completely ordered, but each note is selected in a random fashion with a probability which depends upon preceding notes. Such a machine has been developed and has been operated to generate a sequence of an almost infinite series of notes according to trinote probabilities found in the music of Stephen Foster. Combined with sound synthesizers, the machine provides additional instrumentation for the musical laboratory. However, the ultimate output of even the best-equipped laboratory still depends upon the composer.

HARRY F. OLSON, HERBERT BELAR
R.C.A. Laboratories

Optical-Maser Oscillations in a Gaseous Discharge

The use of a gaseous discharge for obtaining a medium to amplify electromagnetic radiation at an optical frequency will be discussed [A. Javan, *Phys. Rev. Letters* **3**, 518 (1959); A. Javan, in *Quantum Electronics*, C. H. Townes, Ed. (Columbia Univ. Press, New York, 1960)]. Particular emphasis will be given to the case of a gaseous discharge consisting of a mixture of He and Ne, in which the predominant mode of excitations of several excited states of Ne is achieved by means of inelastic collisions of He(2^3S) metastable and Ne atoms. This system has been used [A. Javan, W. R. Bennett, Jr., D. R. Herriott, *Phys. Rev. Letters* **6**, 3 (1961)] to achieve continuous-wave optical-maser oscillations at several frequencies in the near infrared. The short-term stability of the maser oscillation is better than one part in 10^{11}. The coherence and directionality of the output of the maser and some of its applications will be discussed.

A. JAVAN
Bell Telephone Laboratories

Report on the Free Oscillations of the Earth

Free oscillations of the earth have been observed after two earthquakes. Comparison of observed frequencies with theoretical predictions shows excellent agreement. Investigators from the California Institute of Technology, Columbia University, University of California at Los Angeles, and Weizmann Institute are associated with this initial work.

In addition to deducing the properties of the earth's interior from the frequencies of the various modes and the Q of the oscillations, other experiments occur to us. Information concerning the earthquake mechanism can be obtained from phase relationships. Searches can be made for oscillations excited by sources other than earthquakes with improvements in signal-to-noise made possible by prior knowledge of the natural frequencies.

New instrumental approaches involving both strain and pendulum seismographs with digital outputs are being made.

FRANK PRESS, HUGO BENIOFF
Seismological Laboratory,
California Institute of Technology

Concerning a Free Mode of the Earth's Inner Core Possibly Observed during the Chilean Earthquake

The solid inner core of the earth may theoretically execute a rigid-body vibration within the surrounding fluid outer core under excitation by a large earthquake. The gravitational effects of the associated displacements were possibly observed by a LaCoste-Romberg earth-tide gravimeter after the Chilean earthquake of last May. The nature of this gravitational evidence is discussed. Assuming for purposes of discussion that the observations are valid, the free-period (86 minutes) is about 50 percent less than would be expected if only gravitational restoring forces were operative. The required magnitude and nature of additional restoring forces is discussed. The low time-rate of decay of the vibration indicates that the energy dissipation in the material of the fluid outer core is surprisingly low.

LOUIS B. SLICHTER
University of California, Los Angeles

Many Electron Theory of Atoms and Molecules

To predict the chemical and spectroscopic properties of atoms and molecules, correlations in the motions of electrons must be taken into account. So far this has been done successfully only in two electron systems, for example, He and H_2. In larger systems the motions of progressively two, three, four, . . . electrons at a time can be considered as in the theory of imperfect gases. However, the numbers of triplets, quadruplets, and so fourth, increase much faster than the number of pairs as the total number of electrons increases. Our theory reduces this many electron problem to several He- or H_2-like problems by showing why three, four, and larger numbers of electron correlations should be small. Only pairs are needed. Any two electrons, while moving in the "sea" of all the others, affect one another through a correlation potential which is of short range. The "sea" acts on the pair through its Hartree-Fock potential. The theory does not depend on any perturbation expansion. Any pair-wave function can be obtained by minimizing a simple expression just as in He or H_2. The validity of the theory is demonstrated on Be and LiH.

OKTAY SINANOGLU
Yale University

A Requirement for Genetically Specific DNA in the Cell-Free Synthesis of the Enzyme β-Galactosidase

A cell-free system, from pre-induced cells of *Escherichia coli* consisting of particles and supernatant from centrifugation at 105,000 *g*, catalyzes the *de novo* synthesis of β-galactosidase [T. Kameyama and G. D. Novelli, *Biochem. Biophys. Research Communs.* **2**, 393 (1960)]. When the system is properly supplemented with inducer, amino acid, a source of energy, and nucleoside di- and triphosphates, it is capable of effecting a two- to fourfold increase in enzyme activity. A striking inhibition of enzyme synthesis occurs in the presence of deoxyribonuclease. A similar inhibition is seen when the supernatant is exposed to sound waves or ultraviolet light or both. This inhibition can be overcome by the addition of DNA from normal supernatant. X-irradiation of pre-induced cells also inhibits further enzyme synthesis. Mixed experiments with particles and supernatants from normal and x-rayed cells showed that x-irradiation had damaged a component of the supernatant. This component could be replaced with DNA from normal supernatant, and enzyme synthesis in the cell-free system was completely restored. DNA from pre-induced cells of the inducible strain or from the uninduced constitutive mutant restores enzyme synthesis to the cell-free system from x-irradiated cells. DNA from uninduced cells or from a lactose-negative mutant (lacking the gene for β-galactosidase) as well as DNA's from other sources are completely ineffective in the restoration of x-ray damaged enzyme synthesis. These experiments as well as those with different types of DNA will be presented, and the significance of the results will be discussed with respect to the mechanisms involved in induction and repression.

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T. KAMEYAMA
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Relationship of Structure to Activity of Ribonuclease

The availability of a working hypothesis for the chemical structure of bovine pancreatic ribonuclease has encouraged efforts to understand the specific features of the molecule which endow it with catalytic activity. Chemical alterations that cause inactivation have been used by a number of investigators for this purpose. Iodoacetic acid has been a particularly useful reagent. At *p*H 6, alkylation of a single one of the four histidine residues of ribonuclease occurs with the formation of one major, inactive derivative. From the work of W. D. Stein and Barnard [*J. Mol. Biol.* **1**, 339, 350 (1959)], it may be assumed that the residue involved is the histidine at position 119. Crestfield has found that the reaction is specifically oriented toward the nitrogen atom in the 1-position of the imidazole ring of this histidine. The alkylation is abolished by inhibitors of enzymic activity, such as cytidylic acid or cupric ion, and by procedures which alter the tertiary structure of the molecule, such as rupture of the disulfide bonds or exposure to denaturing agents. For these reasons, the histidine residue at position 119 has been placed at the "active site" of the enzyme. Special characteristics of this histidine reaction suggest that a second histidine residue is also involved at the active site. Studies by Anfinsen [*J. Biol. Chem.* **221**, 405 (1956)], Richards and Vithayathil [*Brookhaven Symposia in Biol. No. B* (1960)], and Hirs *et al.* (Proc. Symp. on Biological Structure and Function, Stockholm, 1960) make it probable that the aspartic acid residue at position 121, the asparagine residue at position 15, and the lysine residue at position 41, may all also be at or near the active site. Thus, by the discriminating use of chemical methods, the nature of the active site and certain aspects of the three-dimensional folding of the molecule are slowly being revealed.

WILLIAM H. STEIN, GEORGE R. STARK
Rockefeller Institute

The Extreme Ultraviolet Spectrum of the Sun

The character of the solar spectrum in the extreme ultraviolet is now fairly well known and much can be said about the origin of these radiations. The general picture is of ultraviolet radiation emitted from regions higher in the atmosphere, the shorter the wavelength. Short of 2085 A the Fraunhofer lines fade and become replaced by emission lines. The continuum extends at least to 800 A; from 1400 to 1280 A its brightness temperature is 4700°K. Hence in this spectral range it must originate near the temperature minimum between the photosphere and the chromosphere. From 1280 to 800 A the spectrum is dominated by the Lyman series of hydrogen. Lyman-α is intense, 1-A broad at half-maximum, strongly self-reversed, and with broad damping wings which merge into the continuum within 60 to 100 A. A faint continuous background extends through the entire Lyman series, whose members are resolved through kappa, and is followed by the Lyman continuum, at 6600°K brightness temperature and detectable to 800 A. Most of about 200 emission lines are identified. They are the lines of greatest laboratory intensity, of the most abundant light elements in the sun through sulfur, in states of ionization as high as the eleventh. The lithiumlike isoelectronic sequence is especially complete, with the resonance lines of C IV, N V, O VI, Ne VIII, Mg X, and Si XII, distributed down the spectrum from 1548 to 499 A, forming a sequence whose origins ascend from the low chromosphere into the corona.

R. TOUSEY, J. D. PURCELL, C. R. DETWILER
U.S. Naval Research Laboratory

Development of Gaseous Masses of Lunar Mass

It has been postulated that a solar nebula existed having a mass of about one-third $M_\odot$ and that this broke up into a large number of spherical masses of the order of that of the moon plus its cosmic gases. Such masses would contract because of the loss of energy and mass and would develop various pressures and temperatures

on their interiors. Ideal gas laws have been used in the past to estimate these temperatures and pressures as functions of the mass and radius. In this paper a progress report on the treatment of such spheres by using the current estimates for the nonideal gas laws for hydrogen-helium mixtures will be given. The relation of these calculations to current suggestions regarding the origin of meteorites and planets will be discussed.

H. C. Urey, Janet Bainbridge
University of California, San Diego

On The Participation of Deoxyribonucleic Acid in Ribonucleic Acid Biosynthesis

An enzyme system, first observed by this laboratory in rat liver particles and now found in a number of different organisms, has been described for the biosynthesis of ribonucleic acid. The reaction catalyzed by this enzyme is specific in that it requires the presence of all four ribonucleotide triphosphates as well as DNA. Because of the importance of DNA as an agent of genetic information, it was necessary to gain some insight as to the role played by DNA in this reaction.

With a partially purified enzyme prepared from extracts of *M. lysodeikticus*, RNA was synthesized, in vitro, in the presence of a number of DNA's isolated from various sources. Analysis of the RNA formed showed that with different DNA's the relative position of one ribonucleotide next to its neighbor nucleotide was altered. This information suggested that, in this DNA-requiring reaction, the sequential arrangement of bases in DNA was influencing the arrangement of bases assembled in the RNA molecule. Furthermore, when the base composition of the newly synthesized RNA was determined, it appeared very similar to the base composition reported for the various DNA's used. The data suggest that, in the presence of a specific DNA, it is possible that this enzyme will synthesize complementary ribopolynucleotides.

Samuel B. Weiss
Argonne Cancer Research Hospital and *University of Chicago*

Electricity as Lines of Force Trapped by Topology

The standard equations of Einstein for general relativity and of Maxwell for the electrodynamics of charge free space can be rephrased (Rainich and Misner) in a form that makes no reference to any quantities other than geometrical. The resulting "geometrodynamics" provides a model for the physical world built upon curved empty space—and its dynamical evolution with time—and nothing more (i) which presumably—even after quantization—cannot predict the properties of elementary particles but (ii) which even at the classical level is richer by far in consequences than any nongeometrical theory of physics. Without any inventions or changes it predicts (i) the equations of motion of concentrations of mass-energy (Einstein-Infeld-Hoffman), (ii) the ability of certain kinds of concentrations of electromagnetic and gravitational wave energy (geons) to hold themselves together—as objects endowed with mass—for long periods of time under their own gravitational attraction, and (iii) the existence of equal and opposite charges under circumstances when lines of force are trapped in the topology of a multiply connected space. Nowhere inside of these masses and charges is there anywhere where one can put his finger and say here there is "real mass" or "real charge." Nor is there any evidence that these pencil and paper constructs—of macroscopic size—have the slightest direct connection with the world of elementary particles. However, it is difficult to escape the conclusion that the geometrodynamic type of electric charge can be created under extreme conditions of space curvature ("point A") if general relativity is correct. It is also unreasonable to postulate two kinds of electricities—one geometrical, the other some kind of magic jelly—when economy of concepts would seem to demand a single explanation for electricity. On this basis it would appear difficult to escape from the conclusion that *all* electricity arises from trapping lines of force. The evidence on point A will be reviewed. The absence of *magnetic* charges ("point B") will be discussed in connection with the existence of the electromagnetic four-potential.

John A. Wheeler
Princeton University

Present Status of the Juvenile Hormone

The corpora allata of insects are known to be the source of a "juvenile hormone" which opposes or prevents insect metamorphosis. The presence of the juvenile hormone in the blood and tissues of the immature insect causes growth to proceed without metamorphosis. The hormone is therefore a conservative factor which blocks "growing up" without interfering with growth in an unchanging state.

Five years ago the first active extracts of juvenile hormone were prepared from the abdomens of adult male *Cecropia* moths. Subsequently, the hormone has been subjected to extensive purification. Preliminary infrared and nuclear magnetic resonance studies suggest that the active principle is a water-insoluble lactone rich in methyl and methylene functions.

The vast majority of mammalian tissues contain low concentrations of a substance which is indistinguishable from the juvenile hormone when purified and tested on insects. The most active extracts have been prepared from the thymus and adrenal cortex of calves, and from human placentae. Thus far, nothing is known about the biological activity of the juvenile hormone in mammals or other vertebrates; studies of this type will presumably become feasible after the hormone has been characterized and synthesized.

According to my recent findings, the action of the juvenile hormone on the cells and tissues of insects is associated with its ability to block the de-repression and decoding of fresh genetic "information" without interfering with the use and re-use of information already at the disposal of the cells. Therefore, the hormone favors growth in an unchanging state. This study was supported in part by a grant from the Division of General Medical Sciences of the National Institutes of Health.

Carroll M. Williams
Harvard University

Quantum Mechanical Measurements

The theory of quantum mechanical measurements was formulated most precisely by von Neumann. According to his ideas, the theory consists in the establishment of a statistical correlation between the state of the object on which the measurement is taking place and the state of the measuring apparatus. The "reading" of the apparatus consists in determining in which of several possible states the apparatus is; the statistical correlation between apparatus and object after the measurement is such that the state of the apparatus determines the state of the object, and that this latter state is one of the eigenfunctions of the operator which is being measured. It has been shown some time ago that only those operators can be measured precisely in this way which commute with all additive conserved quantities, such as the components of the angular momentum. As a result, we find that there are, from the point of view of measurability, three types of quantities. The precisely measurable quantities's operators commute with all additive conserved quantities; the collision matrix belongs to this category. Most quantities can only be measured approximately, the possible degree of approximation increasing with the measuring instrument's content of the conserved quantities. Finally, there are quantities which cannot be measured at all; this gives rise to the so-called superselection rules.

E. P. Wigner, M. Yanase
Princeton University

Some Recent Results in the Study of Molecular Structure

Microwave spectroscopy has been applied to the determination of the detailed quantitative structure and other properties of increasingly complicated molecules. Molecules showing several forms differing by internal rotations can now be treated. In addition, energy barriers to internal rotation, dipole moments, nuclear quadrupole coupling constants, and other properties can be obtained with a new degree of detail. Thus not only the magnitude but the direction of dipole moments as well as their dependence on vibrational state and isotope substitution can be determined. Barriers to internal rotation can be used to gain new insight into nonbonded forces. Results will be discussed for a number of recently studied molecules.

E. Bright Wilson, Jr.
Harvard University

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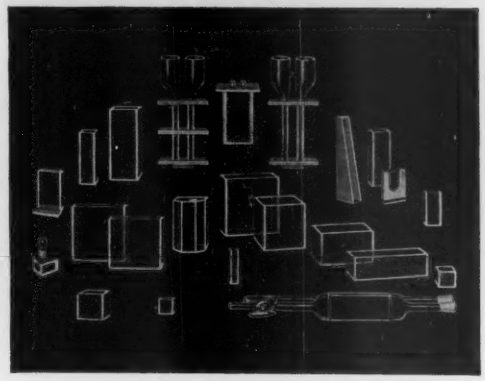

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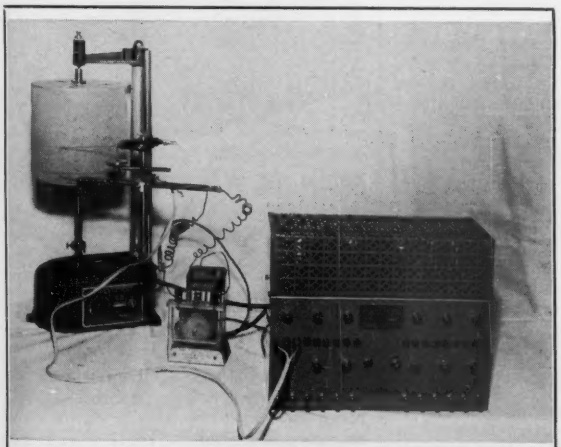

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May

22–24. American Thoracic Soc., Cincinnati, Ohio. (F. W. Webster, 1790 Broadway, New York 19)

22–24. Global Communications, 5th natl. symp., Chicago, Ill. (R. D. Slayton, 5555 Touhy Ave., Skokie, Ill.)

22–24. Telemetering Conf., natl., Chicago, Ill. (J. Becker, AC Spark Plug Division, General Motors Corp., Milwaukee 1, Wis.)

22–25. American Urological Assoc., Los Angeles, Calif. (W. P. Didusch, 1120 N. Charles St., Baltimore 1, Md.)

22–25. Design Engineering Conf. and Show, Detroit, Mich. (ASME Meetings Dept., 29 W. 39 St., New York 18)

22–25. National Tuberculosis Assoc., Cincinnati, Ohio. (J. G. Stone, 1790 Broadway, New York 19)

22–26. Engineering Conf. and Exhibit, 29th annual, New York, N.Y. (G. E. Seeley, ASTME Headquarters, 10700 Puritan Ave., Detroit 38, Mich.)

22–26. Society of Photographic Scientists and Engineers, annual, Binghamton, N.Y. (M. G. Anderson, Ansco, Vestal Parkway East, Binghamton, N.Y.)

22–27. International Acad. of Legal Medicine and of Social Medicine, 5th cong., Vienna, Austria. (M. Helpern, Chief Medical Examiner, City of New York, 55 East End Ave., New York 28)

23–25. Large Capacity Memory Techniques for Computing Systems, symp., Washington, D.C. (Miss J. Leno, Code 430A, Office of Naval Research, Washington 25)

25. Gastroenterology Research Group, Chicago, Ill. (N. C. Hightower, Scott and White Clinic, Temple, Tex.)

25–26. Medical Technology, symp., Cleveland, Ohio. (J. W. King, Cleveland Clinic, 2020 E. 93 St., Cleveland 6)

25–26. Nitro Aliphatic Chemistry, symp., Lafayette, Ind. (Purdue Memorial Union, Purdue Univ., Lafayette)

25–26. Operations Research Soc. of America, 9th annual, Chicago, Ill. (D. Schiller, Gaywood-Schiller Associates, 203 N. Wabash Ave., Chicago 1)

26–27. American Otological Soc., Lake Placid Club, Essex County, N.Y. (J. A. Moore, 525 E. 68 St., New York 21)

26–27. Biology of the Trachoma Agent, symp., New York, N.Y. (F. B. Gordon, Natl. Naval Medical Center, Bethesda 14, Md.)

26–27. Cardiovascular Tissue Culture Conf., Dover, Del. (O. J. Pollak, Dover Medical Research Center, Inc., P.O. Box 228, Dover)

26–3. American Acad. of Dental Medicine, cruise to Bermuda and Nassau. (H. Ward, 15 Bond St., Great Neck, N.Y.)

28–1. Special Libraries Assoc., 52nd annual, San Francisco, Calif. (B. M. Woods, SLA, 31 E. 10 St., New York 3)

29–31. American Gynecological Soc., Colorado Springs, Colo. (A. H. Aldridge, 899 Park Ave., New York 21)

29–31. Cancer Symp., 6th annual, Regina, Saskatchewan, Canada. (A. J. S. Bryant, Allan Blair Memorial Clinic, Regina)

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29–31. Chemical Inst. of Canada, 44th annual, Ottawa. (Chemical Inst. of Canada, 48 Rideau St., Ottawa 2)

29–3. Molecular Spectroscopy, 5th European cong., Amsterdam, Netherlands. (D. H. Zijp, Secy., Nieuwe Achtergracht 123, Amsterdam-C.)

30. Nutrition Soc. of Canada, 4th annual, Guelph, Ontario. (E. V. Evans, Dept. of Nutrition, Ontario Agricultural College, Guelph)

31–2. Canadian Federation of Biological Societies, Guelph, Ontario, Canada. (E. H. Bensley, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

31–2. Radar symp., 7th annual, Ann Arbor, Mich. (Coordinator, 7th Annual Radar Symposium, Institute of Science and Technology, Box 618, Ann Arbor)

June

2–3. Canadian Soc. for Clinical Chemistry, annual general meeting, Guelph, Ont. (C. R. Cameron, Ontario Veterinary College, Guelph)

2–5. Latin-American Congress of Physical Medicine, Lisbon, Portugal. (C. Lopez de Victoria, 245 E. 17 St., New York, N.Y.)

3–11. Medical-Surgical Film Festival, 4th intern., Turin, Italy. (Minerva Medica, Corso Bramante 83–85, Turin)

4–9. Mass Spectrometry, ASTM Committee E-14, Chicago, Ill. (G. Crable, Gulf Research Center, P.O. Box 2038, Pittsburgh 30, Pa.)

4–10. World Congress of Psychiatry, 3rd, Montreal, Canada. (A. Roberts, Allan Memorial Inst., 1025 Pine Ave. West, Montreal 2, P.Q.)

4–12. Cellular Regulatory Mechanisms, 25th Cold Spring Harbor Symp. on Quantitative Biology, Cold Spring Harbor, N.Y. (A. Chovnick, Long Island Biological Assoc., Cold Spring Harbor)

5–7. American Soc. for Quality Control, Philadelphia, Pa. (W. P. Youngclaus, Jr., 161 W. Wisconsin Ave., Milwaukee 3, Wis.)

5–7. Fundamental Aspects of Radiosensitivity, symp., Upton, N.Y. (A. H. Sparrow, Brookhaven National Laboratory, Upton, L.I.)

5–8. International Instrument-Automation Conf. and Exhibit, Instrument Soc. of America, Toronto, Canada. (I.S.A., 313 Sixth Ave., Pittsburgh 22, Pa.)

5–9. Animal Reproduction, 4th intern. cong., Amsterdam, Netherlands. (Secretariat, Burgemeester de Monchyplein 14, The Hague, Netherlands)

5–9. Effects of Ionizing Radiation on the Nervous System, symp., Vienna, Austria. (J. Burt, International Atomic Energy Agency, United Nations, New York, N.Y.)

5–10. International Colloquium on Spectroscopy, 9th, Lyon, France. (Secretariat, Groupement pour l'Avancement des Méthodes Spectrographiques, 1, rué Gaston Boissier, Paris 15)

5–16. Operations Research and Systems Engineering, Baltimore, Md. (Dean, School of Engineering, Johns Hopkins Univ., Baltimore 18)

6–8. Tissue Culture Assoc., 12th annual, Detroit, Mich. (F. E. Payne, Dept. of Epidemiology, Univ. of Michigan, Ann Arbor)

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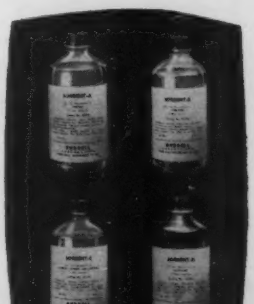

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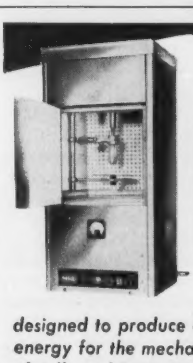

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8–11. American Electroencephalographic Soc., Atlantic City, N.J. (G. A. Ulett, Malcolm Bliss Mental Health Center, 1420 Grattan, St. Louis 4, Mo.)

8–18. International Organization for Standardization, general assembly (members only), Finland. (American Standards Association, 70 East 45 St., New York 17)

9–11. Society of Biological Psychiatry, Atlantic City, N.J. (G. N. Thompson, 2010 Wilshire Blvd., Los Angeles 57, Calif.)

9–17. European Convention of Chemical Engineering, Frankfurt, Germany. (DECHEMA, Postfach No. 7746, Frankfurt/Main 7)

11–15. American Soc. of Mechanical Engineers, summer annual, Los Angeles, Calif. (O. B. Schier II, 29 W. 39 St., New York 18)

12–13. Radio Frequency Interference, 3rd natl. symp., Washington, D.C. (E. F. Mischler, National Engineering Service, Washington, D.C.)

12–14. American Dairy Science Assoc., Madison, Wis. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

12–14. American Neurological Assoc., Atlantic City, N.J. (M. D. Yahr, Neurological Inst., 710 W. 168 St., New York 32)

12–14. Society for the Study of Development and Growth, regeneration symp., Williamstown, Mass. (A. C. Braun, Rockefeller Inst., New York 21)

12–15. Nature of the Real, conf., Milwaukee, Wis. (E. D. Simmons, Dept. of Philosophy, Marquette Univ., Milwaukee 3)

12–15. Physics of Electronic and Atomic Collisions, intern. conf., Boulder, Colo. (B. Bederson, Physics Dept., New York Univ., New York 53)

12–16. Association of Official Seed Analysts, Richmond, Va. (D. D. Forsyth, Agronomy Building, Madison 6, Wis.)

12–16. Molecular Structure and Spectroscopy, symp., Columbus, Ohio. (R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State Univ., Columbus 10)

12–18. European Assoc. for Animal Production, 8th intern. cong., Hamburg, Germany. (European Assoc. for Animal Production, Via Barnaba Oriana 28, Rome, Italy)

12–24. European Inst. of Scientific Studies for the Prevention and Treatment of Alcoholism, Amsterdam, Netherlands. (D. Ehlbeck, Intern. Bureau against Alcoholism, Case Gare 49, Lausanne, Switzerland)

12–29. Statistical Quality Control Intensive Courses for the Chemical and Processing Industries, 18th annual, Rochester, N.Y. (H. M. Kentner, Extended Services Div., Rochester Inst. of Technology, Rochester 8)

13–14. Product Engineering and Production, 5th natl. conf., Philadelphia, Pa. (P. J. Riley, R.C.A., Building 10-6, Camden 2, N.J.)

13–16. Gas Chromatography Symp., 3rd biennial, East Lansing, Mich. (J. E. Callen, Procter and Gamble Co., Miami Valley Laboratories, P.O. Box 175, Cincinnati 39, Ohio)

13–16. Institute of Aerospace Sciences and American Rocket Soc., Los Angeles, Calif. (Inst. of Aerospace Sciences, 2 E. 64 St., New York 21)

13–18. Nuclear Congress, 6th, Rome, Italy. (Ufficio Stampa e Relazioni Pubbliche-CNEN, Via Belisario 15, Rome)

14–16. Applied Mechanics Conf., Chicago, Ill. (American Soc. of Mechanical Engineers, Meetings Dept., 29 W. 39 St., New York 18)

14–16. Semiconducting Compounds, conf., Schenectady, N.Y. (W. W. Tyler, General Electric Research Laboratory, Schenectady)

14–16. Theory of Weak and Strong Interactions, conf., La Jolla, Calif. (T. A. Manar, Scripps Institution of Oceanography, La Jolla)

14–17. American Assoc. of Bioanalysts, Dallas, Tex. (L. D. Hertert, 490 Post St., Room 1049, San Francisco 2, Calif.)

16–17. Meteoritical Soc., Nantucket, Mass. (G. L. Rowland, Long Beach City College, Long Beach 8, Calif.)

17–21. American Nuclear Soc., Boston Mass. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

18–21. American Astronomical Soc., Nantucket, Mass. (J. A. Hynek, Dearborn Observatory, Northwestern Univ., Evanston, Ill.)

18–23. American Meteorological Soc., 193rd natl., and Pacific Div., AAAS, 42nd annual, Davis, Calif. (AMS, 45 Beacon St., Boston 8, Mass.)

18–23. American Soc. of Medical Technologists, Seattle, Wash. (Miss R. Matthaei, Suite 25, Hermann Professional Bldg., Houston 25, Tex.)

19–21. American Soc. of Pharmacognosy, annual summer meeting, Houston, Tex. (R. S. Westby, Eli Lilly and Co., 740 S. Alabama St., Indianapolis 6, Ind.)

19–23. Conference on Carbon, 5th biennial, University Park, Pa. (Fifth Carbon Conf., Pennsylvania State Univ., Conference Center, University Park)

19–24. Feed Microscopy, annual meeting and special short course, Denver, Colo. (C. Jones, Colorado Department of Agriculture, 3130 Zuni St., Denver 11)

19–30. Astrophysics Seminar, Cloudcroft, N.M. (J. R. Foote, P.O. Box 1053, Holloman Air Force Base, N.M.)

21–1. International Plastics Exhibition and Convention, London, England. (British Plastics, Dorset House, Stanford St., London, S.E.1)

22–23. American Rheumatism Assoc., Dallas, Tex. (F. E. Demartini, 622 W. 168 St., New York 32)

22–23. Computers and Data Processing, 8th annual symp., Estes Park, Colo. (W. H. Eichelberger, Denver Research Inst., Univ. of Denver, Denver, Colo.)

22–24. Endocrine Soc., New York, N.Y. (H. H. Turner, 1200 N. Walker, Oklahoma City 3, Okla.)

22–26. American College of Chest Physicians, New York, N.Y. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

23–25. American College of Angiology, 7th annual, New York, N.Y. (A. Halpern, Secretary, 11 Hampton Court, Great Neck, N.Y.)

25–28. American Soc. of Agricultural Engineers, annual, Ames, Iowa. (J. L. Butt, 420 Main St., St. Joseph, Mich.)

(See issue of 21 April for comprehensive list)

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New Products

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■ ALPHA PARTICLE COUNTER (Fig. 1) for classroom demonstration is an open-air spark type. Particles are detected by small sparks that occur whenever a particle ionizes a path in the air between the counter's nickel-chromium grid and detector plate. An accessory power supply maintains a potential of about 5000 v between the grid and the plate. The source of alpha radiation is mounted on a rod that can be adjusted in relation to the counter grid. A clear plastic cover protects the radioactive source from student contact and dust. (Central Scientific Co., Dept. Sci169, 1700 Irving Park, Chicago 13, Ill.)

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■ REFRIGERATED CONTINUOUS-FLOW CENTRIFUGE develops 28,000 grav at 18,750 rev/min. Automatic temperature control of materials within the continuous-flow rotor is provided. Feeding of sample and coolant is controlled by a metered pump system. Sample delivery and return lines are insulated. A roller-mill assembly permits reconstituting sediments within a rotor. The rotor allows displacement volumes of either 100 or 400 ml, and it can be emptied of certain sediments without opening the rotor or scraping the rotor walls. (Spinco Div., Beckman Instruments, Inc., Dept. Sci157, Stamford Industrial Park, Palo Alto, Calif.)

■ MICROVOLT POTENTIOMETER has a range of 0 to 1110 μv with a resistance of 100 ohm/mv. The power source is a built-in saturated standard cell which is said to be capable of supplying the 10-μa current drawn by the potentiometer for long periods of time without damage. The instrument is designed to compare two voltages that are within 0.1 percent of each other within 1 μv directly, or within a fraction of a microvolt by interpolation on a galvanometer. (Physics Research Laboratory, Dept. Sci166, P.O. Box 555, Hempstead, N.Y.)

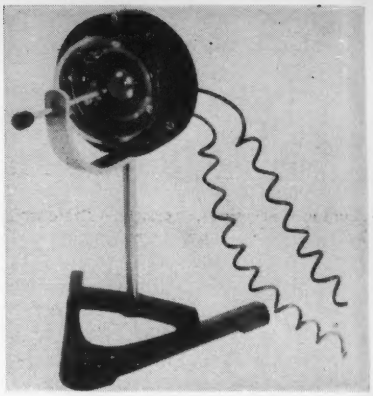

Fig. 1. Alpha particle counter.

■ VOLTAGE DIVIDER is relay-operated with accuracy said to be ± 0.003 percent over the unit's full service life and range of operation. The divider response time is less than 15 msec; thus it is suitable for operation by keyboard, punched paper tape, or punched cards. Dimensions are 3.75 by 7.25 by 1.25 in. Multiple units may be stacked vertically on 1.5-in. centers. (Julie Research Laboratories, Inc., Dept. Sci179, 603 W. 130 St., New York 27)

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■ INFRARED SPECTROPHOTOMETER is a flat-bed type recording instrument covering the range of 650 to 5000 wave numbers in a scanning time of 10 min. The scan may be stopped and started at any point. The photometer is of the double-beam type with a Nernst filament radiation source. Radiation entering the monochromator is interrupted at a 10 cy/sec rate; slits are programmed for constant energy; the level of the program may be varied. The dispersing element is a 60-deg, rock-salt prism; the radiation detector is a Golay cell. A potentiometer accessory permits any chosen portion of the transmittance scale to be expanded on an external recorder. A variety of sample cells is available. (Unicam Instruments Ltd., Dept. Sci159, Asbury Works, Cambridge, England)

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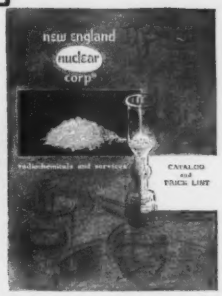

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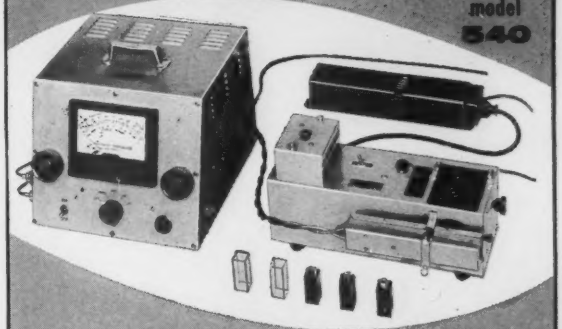

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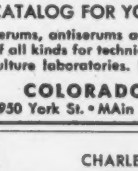

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